DEPARTMENT OF THE INTERIOR,

CENSUS OFFICE.

FRANCIS A. WALKER, Superintendent,
Appointed April 1, 1879; resigned November 3, 1881.

CHAS. W. SEATON, Superintendent,
Appointed November 4, 1881. Office of Superintendent abolished March 3, 1885.

STATISTICS OF POWER AND MACHINERY EMPLOYED IN MANUFACTURES.

PROF. W. P. TROWBRIDGE,
CHIEF SPECIAL AGENT.

REPORTS

ON THE

WATER-POWER OF THE UNITED STATES.

PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., December 29, 1885.

Hon. L. Q. C. LAMAR,
Secretary of the Interior.

SIR: I have the honor to transmit herewith the sixteenth and seventeenth volumes of the quarto series comprising the final report on the Tenth Census, namely, that devoted to the water-power of the United States, prepared under the direction of Professor W. P. Trowbridge, of the School of Mines, Columbia College, New York, N. Y., chief special agent.

The report comprises the following-named monographs:

PART I.

Streams of eastern New England .... Swain.
Region tributary to Long Island sound .... Porter.
Hudson River basin and Lake George outlet .... Porter.
Region tributary to lake Ontario and the New York state canals .... Porter.
Drainage basins of lakes Huron and Erie, and water-power of Niagara falls and river .. Greenleaf.
Middle Atlantic water-shed .... Swain.
Southern Atlantic water-shed .... Swain.
Eastern Gulf slope .... Porter.

PART II.

The Northwest .... Greenleaf.
Mississippi river and some of its tributaries .... Greenleaf.
Mississippi river on the west, below Dubuque .... Porter.
Ohio River basin and Ohio state canals .... Porter.
Water-supply of certain cities and towns .... Elliot.

The general review and summary which is so strongly commended and approved by Professor Trowbridge was prepared by George F. Swain, Assistant Professor of Civil Engineering in the Massachusetts Institute of Technology, at Boston, Massachusetts.

Very respectfully, your obedient servant,

JAMES H. WARDLE,
Chief of Census Division.

INTRODUCTION

TO THE

REPORTS ON THE WATER-POWER OF THE UNITED STATES.

GENERAL TABLE OF CONTENTS.

PART I.

PART II.

GENERAL LETTER OF TRANSMITTAL.

SCHOOL OF MINES, COLUMBIA COLLEGE,
New York, N. Y., October 12, 1882.

Hon. CHAS. W. SEATON,
Superintendent of Census, Washington, D. C.

SIR: I have the honor to transmit herewith the reports of Messrs. George F. Swain, James L. Greenleaf, and Dwight Porter on the water-power of the United States.

As special agent of the Tenth Census in charge of the collection of statistics of power and machinery, I arranged, at the request of General Francis A. Walker, and under his general direction, the plan of investigations of which the results are embodied in these reports. I have already transmitted the reports of the other special agents selected by me for the collection of statistical information on the other branches of the work under my charge, and the results which I now forward complete the series of investigations intended to cover, so far as practicable, the subject of power and machinery.

The general scheme of inquiries in relation to water-power was arranged in consultation with General Walker before the special agents who were to take the field had been selected. It embraced the examination of the different great water-sheds of the country as they are naturally defined by mountain systems and intermediate slopes and valleys. The investigations were to be conducted by personal explorations and reconnaissances in the field, with the aid of all available maps and other sources of information that could be procured. It was foreseen at once that great care must be taken not to make the examinations so general that the results would have no specific value, nor so much in detail as to preclude the possibility, with the limited force at my disposal, of embracing the entire country east of the Rocky mountains.

For the work thus planned I selected, with General Walker's approval, Mr. George F. Swain, civil engineer, a graduate of the Massachusetts Institute of Technology; Mr. James L. Greenleaf, civil engineer, a graduate of the School of Mines, Columbia College, New York, N. Y.; and Mr. Dwight Porter, a graduate of the Sheffield Scientific School of Yale College, New Haven, Connecticut. These gentlemen remained in the field continually until their investigations were concluded, receiving advice and directions by mail as their work progressed.

I need only refer you to their reports for evidence of the large amount of work which they accomplished.

But these reports do not, and can not, exhibit any evidence of the fatigue and exposures undergone by these gentlemen in their efforts to accomplish within the time allotted the work which was assigned to them.

As contributions to the hydrology of the country, the reports will, I am sure, be found to be of a character not heretofore attempted, and to contain general and specific information of the highest public value and interest.

The whole cost of the work consisted of the very moderate salaries of the three special agents named above, and their necessary traveling expenses.

I have the honor to be, very respectfully, your obedient servant,

W. P. TROWBRIDGE,
Chief Special Agent, Tenth Census.

THE DISTRIBUTION OF UTILIZED POWER IN THE UNITED STATES.

The following table shows the total water- and steam-power in use in 1870 and 1880, with other facts of interest:

	WATER-POWER.			STEAM-POWER.			Total steam- and water-power (horse-power).
	Number of water-wheels.	Horse-power.	Average horse-power per wheel.	Number of steam-engines.	Horse-power.	Average horse-power per steam-engine.	
1880	55, 404	1, 225, 379	22. 12	56, 483	2, 185, 458	38. 69	3, 410, 837
1870	51, 018	1, 130, 431	22. 16	40, 191	1, 215, 711	30. 25	2, 346, 142
Percentage of increase	8. 60	8. 40		40. 54	79. 77		45. 38

From this we see that the total amount of power used in manufactures, both steam and water, has increased 1,064,695 horse-power during the decade. Of this total increase, 94,948 horse-power, or 8.92 per cent., is due to the increase in the amount of water-power used, while 969,747 horse-power, or 91.08 per cent., is due to the increase in the amount of steam-power used. The average power of the water-wheels has slightly diminished, probably on account of the introduction of various forms of small hydraulic motors for light work.

The following table gives the total amounts of water- and steam-power in each state and territory in 1870 and 1880, with the percentage of increase, and the proportional amounts of water- and steam-power. This, however, must be regarded as an approximate comparison only:

State or territory.	WATER-POWER.			STEAM-POWER.			1870.		1880.	
	Total in 1870.	Total in 1880.	Increase.	Total in 1870.	Total in 1880.	Increase.	Water-power.	Steam-power.	Water-power.	Steam-power.
	Horse-power.	*Horse-power.*	*Per cent.*	*Horse-power.*	*Horse-power.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total in the United States.	1, 130, 431	1, 225, 379	8. 40	1, 215, 711	2, 185, 458	79. 77	48. 18	51. 82	35. 93	64. 07
Alabama	11, 011	11, 797	7. 14	7, 740	15, 779	103. 85	58. 72	41. 28	42. 78	57. 22
Arizona	10	160	1, 500. 00	80 (35)	370	957. 14	11. 11	88. 89	30. 19	69. 81
Arkansas	1, 545	2, 024	31. 00	6, 101	13, 709	124. 70	20. 21	79. 79	12. 86	87. 14
California	6, 877 (5, 381)	4, 850	(*a*)	18, 493 (17, 072)	28, 071	64. 43	27. 11	72. 89	14. 73	85. 27
Colorado	792 (742)	1, 849	149. 19	1, 433 (761)	3, 953	419. 45	35. 60	64. 40	31. 87	68. 13
Connecticut	54, 395	61, 205	12. 52	25, 979	57, 027	119. 51	67. 68	32. 32	51. 77	48. 23
Dakota	76	803	956. 58	248	1, 421	472. 98	23. 46	76. 54	36. 11	63. 89
Delaware	4, 220	4, 785	13. 39	4, 313	10, 643	146. 77	49. 46	50. 54	31. 02	68. 98
District of Columbia	1, 100	880	(*a*)	789	2, 263	186. 82	58. 23	41. 77	28. 00	72. 00
Florida	528	939	77. 84	3, 172	6, 208	95. 71	14. 27	85. 73	13. 14	86. 86
Georgia	27, 417 (27, 356)	30, 067	9. 91	10, 826 (10, 811)	21, 102	95. 19	71. 69	28. 31	58. 76	41. 24
Idaho	295 (92)	1, 136	1, 134. 78	311 (191)	546	185. 86	48. 68	51. 32	67. 54	32. 46
Illinois	12, 953	17, 445	34. 68	73, 091	126, 843	73. 54	15. 05	84. 95	12. 09	87. 91
Indiana	23, 518	21, 810	(*a*)	76, 851	109, 960	43. 08	23. 43	76. 57	16. 55	83. 45
Iowa	14, 249	20, 363	42. 91	25, 298	33, 858	33. 84	36. 03	63. 97	37. 56	62. 44
Kansas	1, 789	7, 611	325. 43	6, 360	13, 468	111. 76	21. 95	78. 05	36. 11	63. 89
Kentucky	7, 640	9, 012	17. 96	31, 928	45, 917	43. 81	19. 31	80. 69	16. 41	83. 59
Louisiana	142	90	(*a*)	24, 924 (6, 628)	11, 256	69. 82	0. 57	99. 43	0. 79	99. 21
Maine	70, 108	79, 717	13. 76	9, 465	20, 759	119. 32	88. 11	11. 89	79. 34	20. 66
Maryland	18, 461	18, 043	(*a*)	13, 961	33, 216	137. 92	56. 94	43. 06	35. 20	64. 80
Massachusetts	105, 854	138, 362	30. 71	78, 502 (78, 450)	171, 397	118. 48	57. 42	42. 58	44. 67	55. 33
Michigan	34, 895	34, 395	(*a*)	70, 956	130, 352	83. 71	32. 97	67. 03	20. 88	79. 12
Minnesota	13, 054	28, 689	119. 77	7, 085	25, 191	255. 55	64. 82	35. 18	53. 25	46. 75
Mississippi	2, 453	3, 449	40. 60	10, 019	15, 001	49. 73	19. 67	80. 33	18. 69	81. 31
Missouri	6, 644	8, 162	22. 85	48, 418	72, 587	49. 92	12. 07	87. 93	10. 11	89. 89
Montana	795 (611)	954	56. 14	822 (226)	544	140. 71	49. 17	50. 83	63. 68	36. 32
Nebraska	1, 446	5, 495	280. 01	1, 865	2, 999	60. 80	43. 67	56. 33	64. 69	35. 31
Nevada	2, 538 (370)	108	(*a*)	6, 007 (636)	608	(*a*)	29. 70	70. 30	15. 08	84. 92
New Hampshire	68, 291	69, 155	1. 27	8, 787	18, 595	111. 62	88. 60	11. 40	78. 81	21. 19
New Jersey	25, 832	27, 066	4. 78	32, 307	72, 792	125. 31	44. 43	55. 57	27. 10	72. 90

a Decrease.

State or territory.	WATER-POWER.			STEAM-POWER.			1870.		1880.	
	Total in 1870.	Total in 1880.	Increase.	Total in 1870.	Total in 1880.	Increase.	Water-power.	Steam-power.	Water-power.	Steam-power.
	Horse-power.	*Horse-power.*	*Per cent.*	*Horse-power.*	*Horse-power.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New Mexico	659 (623)	932	49.60	252 (103)	427	314.56	72.34	27.66	68.58	31.42
New York	208,256 (208,106)	219,348	5.40	126,107	234,795	86.19	62.28	37.72	48.30	51.70
North Carolina	26,211 (26,200)	30,063	14.74	6,941 (6,816)	15,025	120.44	79.06	20.94	66.68	33.32
Ohio	44,746	38,641	(*a*)	129,577	222,502	71.71	25.67	74.33	14.80	85.20
Oregon	5,806 (5,766)	9,255	60.51	2,471 (2,451)	4,334	76.83	70.15	29.85	68.11	31.89
Pennsylvania	141,982	110,276	(*a*)	221,936	402,132	81.19	39.01	60.99	21.52	78.48
Rhode Island	18,481	22,240	20.34	23,546	41,335	75.55	43.97	56.03	34.98	65.02
South Carolina	10,395 (10,386)	13,873	33.58	4,537 (4,487)	11,995	16.73	69.62	30.38	53.63	46.37
Tennessee	19,514	18,564	(*a*)	18,467	33,388	80.80	51.38	48.62	35.73	64.27
Texas	1,830	2,508	37.05	11,214	28,026	149.92	14.03	85.97	8.21	91.79
Utah	2,169	3,535	62.98	331 (319)	1,154	261.76	86.76	13.24	75.39	24.61
Vermont	44,897	52,226	16.32	6,425	11,088	72.58	87.48	12.52	82.49	17.51
Virginia	41,202	37,464	(*a*)	8,410	19,710	134.36	83.05	16.95	65.53	34.47
Washington	1,412	1,185	(*a*)	1,411	3,210	127.49	50.02	49.98	26.96	73.04
West Virginia	10,195	9,454	(*a*)	17,136	28,456	66.06	37.30	62.70	24.94	75.06
Wisconsin	33,714	45,356	34.53	30,509	60,729	99.05	52.50	47.50	42.75	57.25
Wyoming	34 (0)	38	....	310 (245)	717	102.65	9.88	90.12	5.03	94.97

a Decrease.

NOTE.—In cases where two figures are given for the steam- or water-power of a state in 1870, those not inclosed in parentheses are the ones returned. Those in parentheses are the figures used in computing the percentages of increase, and have been derived from the former by subtracting power used for purposes which in 1880 were not classified under manufactures. The table thus refers to power used in manufactures as classified in 1880.

In taking the results for these tables from the census returns, it is to be observed that the classification adopted in 1880 is not exactly the same as that of 1870. Thus, from the tables it would appear that there was a falling off in the amount of steam-power used in manufactures in the state of Louisiana from 24,924 horse-power in 1870 to 11,256 horse-power in 1880. This is due to the fact that in the Census of 1870 the sugar made on the plantations direct from the raw cane was included as a product of manufacture, while in 1880 it is included with the products of agriculture. Thus, in order to make a comparison, we must deduct 18,296 horse-power (steam-power) used on the plantations from the total 24,924 horse-power, and we should then have for the industries included in the Census of 1880 an increase from 6,628 horse-power in 1870 to 11,256 horse-power in 1880. In a similar way, some of the items which in 1870 were included under the head of manufactures, such as "quartz, milled", were in 1880 classed among the statistics of mining, and their amounts had to be subtracted from the figures given for 1870. The corrected amounts, taking account of the principal items of this kind, have been included in parentheses in the foregoing table, and in all cases they have been used in computing the percentages of increase. As this report deals with water-power without reference to the use made of it, whether for purposes of manufacture, agriculture, or mining, it would have been better if, instead of subtracting from the amounts given for 1870, we had added to those of 1880, or to both, making both represent the total amount of power used for all purposes; but the necessary statistics were not at hand at the time of writing this introduction, and probably the percentages would in all but a few cases remain approximately the same. The figures given have reference, therefore, to the power used in manufactures only, as classified at the Census of 1880.

This table shows that the steam-power has increased within the decade very much more rapidly than the water-power, the proportion of water-power in the entire country having fallen from 48.18 per cent. in 1870 to 35.93 per cent. in 1880; while it has decreased in every state and territory with the exception of Arizona, Dakota, Idaho, Iowa, Kansas, Louisiana, Montana, and Nebraska. There has also been a decrease, according to the tables, in the actual amount of water-power used in California, the District of Columbia, Indiana, Louisiana, Maryland, Michigan, Nevada, Ohio, Pennsylvania, Tennessee, Virginia, Washington, and West Virginia; but as these figures represent the power used in manufactures only, the total power in use may nevertheless have increased in these states. In every case there has been an increase in the actual amount of steam-power used.

The following table shows the percentage of the total amount of steam- and water-power, of the total amount of water-power, and of the total amount of steam-power for each state and territory; also the rank of each state and territory in regard to amount of power used:

State or territory.	Rank in total power.	Percentage of the total steam- and water-power.	Rank in water-power.	Percentage of the total water-power.	Rank in steam-power.	Percentage of the total steam-power.	State or territory.	Rank in total power.	Percentage of the total steam- and water-power.	Rank in water-power.	Percentage of the total water-power.	Rank in steam-power.	Percentage of the total steam-power.
Alabama	27	0.81	23	0.96	25	0.72	Missouri	13	2.37	27	0.67	9	3.32
Arizona	47	0.02	44	0.01	47	0.02	Montana	43	0.04	39	0.08	45	0.02
Arkansas	31	0.46	35	0.17	28	0.63	Nebraska	35	0.25	29	0.45	38	0.14
California	25	0.97	30	0.40	18	1.28	Nevada	46	0.02	45	0.01	43	0.03
Colorado	37	0.17	36	0.15	36	0.18	New Hampshire	12	2.57	5	5.64	24	0.85
Connecticut	8	3.47	6	4.99	11	2.61	New Jersey	11	2.93	15	2.21	8	3.33
Dakota	41	0.07	43	0.07	40	0.07	New Mexico	44	0.04	41	0.08	46	0.02
Delaware	32	0.45	31	0.39	33	0.49	New York	2	13.31	1	17.90	2	10.74
District of Columbia	40	0.09	42	0.07	39	0.10	North Carolina	23	1.32	13	2.45	26	0.69
Florida	36	0.21	40	0.08	34	0.28	Ohio	4	7.66	9	3.15	3	10.18
Georgia	22	1.50	12	2.45	21	0.97	Oregon	33	0.40	25	0.76	35	0.20
Idaho	46	0.05	38	0.09	44	0.02	Pennsylvania	1	15.02	3	9.00	1	18.40
Illinois	6	4.23	21	1.42	6	5.80	Rhode Island	14	1.86	16	1.81	13	1.80
Indiana	7	3.86	17	1.78	7	5.03	South Carolina	28	0.76	22	1.13	30	0.55
Iowa	18	1.59	18	1.66	14	1.55	Tennessee	20	1.52	19	1.51	15	1.53
Kansas	29	0.62	28	0.62	29	0.62	Texas	26	0.90	34	0.20	19	1.28
Kentucky	17	1.61	26	0.74	12	2.10	Utah	38	0.14	32	0.29	41	0.05
Louisiana	34	0.33	46	0.01	31	0.52	Vermont	15	1.86	7	4.26	32	0.51
Maine	10	2.95	4	6.51	22	0.95	Virginia	16	1.68	10	3.06	23	0.90
Maryland	21	1.50	20	1.47	16	1.52	Washington	39	0.13	37	0.10	37	0.15
Massachusetts	3	9.08	2	11.29	4	7.84	West Virginia	24	1.11	24	0.77	17	1.30
Michigan	5	4.83	11	2.81	5	5.96	Wisconsin	9	3.11	8	3.70	10	2.78
Minnesota	19	1.58	14	2.34	20	1.15	Wyoming	45	0.02	47	(a)	42	0.03
Mississippi	30	0.54	33	0.28	27	0.69							

a Less than 0.004 of 1 per cent.

From this table we see that Pennsylvania stands first in the total amount of power used in manufactures, with 15.02 per cent. of the total for the United States. New York is second, with 13.31 per cent.; Massachusetts third, with 9.08 per cent.; and Ohio fourth, with 7.66 per cent. of the total. In the amount of water-power used, New York is first, with 17.90 per cent.; Massachusetts second, with 11.29 per cent.; Pennsylvania third, with 9 per cent.; and Maine fourth, with 6.51 per cent. of the total. For steam-power we again have Pennsylvania first, with 18.40 per cent.; New York second, with 10.74 per cent.; Ohio third, with 10.18 per cent.; and Massachusetts fourth, with 7.84 per cent. of the total.

It is interesting to compare the amount of power used in each state and territory with the area of that state or territory. For this purpose the following table has been computed. In it the area of each state and territory is given, and the total amount of water- and steam-power, of water-power, and of steam-power, per square mile, with corresponding rank of each state and territory:

State or territory.	Area.	Total water- and steam-power per square mile.	Water-power per square mile.	Steam-power per square mile.	Rank in total power per square mile.	Rank in water-power per square mile.	Rank in steam-power per square mile.
	Square miles.	*Horse-power.*	*Horse-power.*	*Horse-power.*			
Alabama	51,540	0.54	0.23	0.31	28	26	28
Arizona	112,920	0.01	(a)	(a)	43	44	45
Arkansas	53,045	0.30	0.04	0.26	30	33	30
California	155,980	0.21	0.03	0.18	33	35	32
Colorado	103,645	0.06	0.02	0.04	39	36	38
Connecticut	4,845	24.40	12.63	11.77	4	4	4
Dakota	147,700	0.02	0.01	0.01	41	39	40
Delaware	1,960	7.87	2.44	5.43	9	11	8
District of Columbia	60	52.38	14.67	37.72	2	3	2
Florida	54,240	0.13	0.02	0.11	35	37	34
Georgia	58,980	0.87	0.51	0.36	25	19	25
Idaho	84,290	0.02	0.01	0.01	42	40	41
Illinois	56,000	2.58	0.31	2.27	16	25	12
Indiana	35,910	3.67	0.61	3.06	13	17	11
Iowa	55,475	0.98	0.37	0.61	23	23	22

a Less than 0.005 horse-power per square mile.

State or territory.	Area.	Total water- and steam-power per square mile.	Water-power per square mile.	Steam-power per square mile.	Rank in total power per square mile.	Rank in water-power per square mile.	Rank in steam-power per square mile.
	Square miles.	*Horse-power.*	*Horse-power.*	*Horse-power.*			
Kansas	81, 700	0. 26	0. 09	0. 16	31	30	33
Kentucky	40, 000	1. 37	0. 23	1. 15	20	27	16
Louisiana	45, 420	0. 25	(*a*)	0. 25	32	45	31
Maine	29, 895	3. 36	2. 67	0. 69	14	9	21
Maryland	9, 860	5. 20	1. 83	3. 37	12	12	10
Massachusetts	8, 040	38. 53	17. 21	21. 32	3	2	3
Michigan	57, 430	2. 87	0. 60	2. 27	15	18	13
Minnesota	79, 205	0. 68	0. 36	0. 32	27	24	26
Mississippi	46, 340	0. 40	0. 07	0. 32	29	31	27
Missouri	68, 735	1. 17	0. 12	1. 06	22	28	19
Montana	145, 310	0. 01	0. 01	(*a*)	44	41	46
Nebraska	76, 185	0. 11	0. 07	0. 04	37	32	39
Nevada	109, 740	0. 01	(*a*)	0. 01	45	46	42
New Hampshire	9, 005	9. 74	7. 68	2. 06	7	5	14
New Jersey	7, 455	13. 39	3. 63	9. 76	5	8	5
New Mexico	122, 460	0. 01	0. 01	(*a*)	46	42	47
New York	47, 620	9. 54	4. 61	4. 93	8	7	9
North Carolina	48, 580	0. 93	0. 62	0. 31	24	16	29
Ohio	40, 760	6. 41	0. 95	5. 46	11	13	7
Oregon	94, 560	0. 14	0. 10	0. 05	34	29	36
Pennsylvania	44, 985	11. 39	2. 45	8. 94	6	10	6
Rhode Island	1, 085	58. 59	20. 50	38. 10	1	1	1
South Carolina	30, 170	0. 86	0. 46	0. 40	26	20	24
Tennessee	41, 750	1. 24	0. 44	0. 80	21	21	20
Texas	262, 290	0. 12	0. 01	0. 11	36	43	35
Utah	82, 190	0. 06	0. 04	0. 01	40	34	43
Vermont	9, 135	6. 93	5. 72	1. 21	10	6	15
Virginia	40, 125	1. 42	0. 93	0. 49	19	14	23
Washington	66, 880	0. 07	0. 02	0. 05	38	33	37
West Virginia	24, 645	1. 54	0. 38	1. 15	18	22	17
Wisconsin	54, 450	1. 95	0. 83	1. 12	17	15	18
Wyoming	97, 575	0. 01	(*a*)	0. 01	47	47	44

a Less than 0.005 horse-power per square mile.

From this table it appears that New York, which stands first in the total amount of water-power used, stands eighth in rank as regards water-power per square mile, showing but 4.61 horse-power per square mile, while Rhode Island, which stands sixteenth in total water-power, stands first in water-power per square mile, showing 20.50 horse-power per square mile. The close agreement of the figures for the same state in the last three columns is rather remarkable.

The territory of the United States may be divided into five sections, viz: The northern Atlantic states, including all those along the Atlantic coast from Maine to Pennsylvania and New Jersey; the southern Atlantic states, including all those along the coast from Delaware, Maryland, and West Virginia, to Georgia and Florida; the northern central, or middle states, including the remaining states north of Kentucky, Arkansas, Indian territory, and Texas, and east of Montana, Wyoming, Colorado, and New Mexico; the southern central, or middle states, including the states south of the northern boundary of Kentucky, Arkansas, Indian territory, and Texas; and the western states, including all those west of the eastern boundary of Montana, Wyoming, Colorado, and New Mexico.(*a*)

The distribution of power in these sections is shown in the following table:

Divisions.	Total steam- and water-power.	Water-power.	Steam-power.
	Horse-power.	*Horse-power.*	*Horse-power.*
United States	3, 410, 837	1, 225, 379	2, 185, 458
Northern Atlantic	1, 809, 515	779, 595	1, 029, 920
Southern Atlantic	294, 186	145, 568	148, 618
Northern Central	1, 028, 680	228, 770	799, 910
Southern Central	210, 520	47, 444	163, 076
Western	67, 936	24, 002	43, 934

a This is the division followed in the report of Mr. Hollerith, from which the following tables are taken.

In the following table are given the percentage of the total water- and steam-power, of the total water-power, and of the total steam-power used in each of these five divisions:

Divisions.	Percentage of the total water- and steam-power.	Percentage of the total water-power.	Percentage of the total steam-power.
Northern Atlantic	53. 05	63. 62	47. 13
Southern Atlantic	8. 63	11. 88	6. 80
Northern Central	30. 16	18. 67	36. 60
Southern Central	6. 17	3. 87	7. 46
Western	1. 99	1. 96	2. 01

From this we see that 63.62 per cent. of all the utilized water-power of the country, or nearly two-thirds, is in the northern Atlantic states, while the northern Atlantic and northern central states together include about four-fifths of this total. New England alone reports 34.51 per cent. of the total water-power, while all the Atlantic states together include 75.50 per cent., or nearly three-fourths.

The relative amounts of water- and steam-power in these sections of the country are shown in the following table:

Divisions.	Water-power.	Steam-power.
	Per cent.	*Per cent.*
United States	35. 93	64. 07
Northern Atlantic	43. 08	56. 92
Southern Atlantic	49. 48	50. 52
Northern Central	22. 24	77. 76
Southern Central	22. 54	77. 46
Western	35. 33	64. 67

In the following table is given the power per square mile in each of these divisions:

Divisions.	Area in square miles.	Average water- and steam-power per square mile.	Average water-power per square mile.	Average steam-power per square mile.
		Horse-power.	*Horse-power.*	*Horse-power.*
United States	*a* 2, 900, 170	1. 18	0. 42	0. 75
Northern Atlantic	162, 065	11. 16	4. 81	6. 35
Southern Atlantic	268, 620	1. 09	0. 54	0. 55
Northern Central	753, 550	1. 36	0. 30	1. 06
Southern Central	*a* 540, 385	0. 39	0. 09	0. 30
Western	1, 175, 550	0. 06	0. 02	0. 04

a Exclusive of Indian and unorganized territory.

It is interesting to study the distribution of water-power among the more important industries, and the proportion of water- and steam-power used in each. The following table shows for some selected industries the total amount of water-power, the percentage which this total forms of the total water-power of the country; also the percentage of water- and steam-power in the total power used in each industry:

Industries.	1870.				1880.				Average total power (steam and water) used per establishment.	Total number of establishments.
	Total water-power.	Per cent. of total water-power of the United States.	Per cent. of total power in industry.		Total water-power.	Per cent. of total water-power of the United States.	Per cent. of total power in industry.			
			Water-power.	Steam-power.			Water-power.	Steam-power.		
	H. P.				*H. P.*					
Agricultural implements	10, 209	0. 90	39. 14	60. 86	12, 645	1. 03	28. 27	71. 73	34. 92	1, 281
Boots and shoes (factory)	167	0. 01	5. 44	94. 56	410	0. 03	3. 54	96. 46	15. 62	741
Cotton goods (*a*)	99, 073	8. 76	67. 84	32. 16	148, 754	12. 14	53. 99	46. 01	288. 18	956
Flouring- and grist-mill products	407, 950	36. 09	70. 74	29. 26	469, 987	98. 35	60. 94	39. 06	31. 79	24, 258
Foundery and machine-shop products	....	....	....	....	15, 364	1. 25	15. 34	84. 66	23. 79	4, 209
Iron and steel	14, 631	1. 29	9. 72	90. 28	16, 506	1. 35	4. 16	95. 84	508. 64	781
Lumber, sawed	326, 728	28. 90	50. 93	49. 07	278, 686	22. 74	33. 91	66. 09	32. 01	25, 680
Paper	41, 644	3. 68	78. 25	21. 75	87, 611	7. 15	70. 70	29. 30	179. 06	692
Sashes, doors, and blinds	7, 758	0. 69	....	....	6, 505	0. 53	17. 16	82. 84	33. 48	1, 132
Silk and silk goods	789	0. 07	41. 29	58. 71	1, 562	0. 13	17. 73	82. 27	44. 72	197
Woolen goods	52, 906	4. 68	62. 17	37. 83	53, 610	4. 38	50. 33	49. 67	53. 68	1, 984
Worsted goods	4, 634	0. 41	57. 81	42. 19	6, 302	0. 51	38. 34	61. 66	216. 28	76

a Including both specific and special cotton-mills.

The maps and diagrams accompanying the report on the *Statistics of Power used in Manufactures*, by Mr. Herman Hollerith, E. M., Special Agent of the Tenth Census, inserted in the volume on manufactures, illustrate the facts shown by these statistics.

The four maps illustrate the distribution of power used in manufactures, No. 1 being for the total power, No. 2 for water-power, and No. 3 for steam-power. "In the compilation of these maps, the county was taken as the unit, the average amount of power per square mile was computed for each county, and that county ranked from I to VI, as shown in the legend of the maps." West of the 90th meridian the amount of power used is so small that that region was not included in the maps. The fourth map shows the relative importance of water- and steam-power in various sections of the country. The following description of the plates is reprinted from the volume on the *Manufactures of the United States at the Tenth Census:*

Plate I is a graphical comparison of the statistics of power used in manufactures as returned at the Tenth Census, with similar statistics as returned at the Ninth Census. The plate shows the relation of steam- and water-power, and the distribution of the total amount of power among certain leading industries in 1870 and in 1880.

Plate II shows the distribution of power by states and territories, and the relative importance of steam- and water-power in each, as returned at the Census of 1880.

Plate III is a comparison of the statistics of power used in certain leading industries as returned at the Census of 1870 and that of 1880.

These statistics illustrate very clearly some points regarding the commercial availability and value of water-power which it may be well briefly to consider here.

In comparing water-power with steam-power, the most striking point of difference, and one which at the same time constitutes a great advantage in favor of the latter, is the fact that steam-power is mobile and may be used wherever fuel can be obtained, independently of any particular location. Mills using steam-power may therefore be located in positions most favorable for economical production and for quick disposal of the finished product. Convenient facilities for transportation constitute, therefore, a most important factor affecting the value of a water-power, and many powers which are technically all that could be desired are rendered almost valueless by the lack of this essential element, unless, as in some cases, the raw material is produced and the finished product disposed of in the immediate vicinity. A perusal of the pages of this report will show that generally water-power is much cheaper than steam-power, but the former can not be moved, the factory must be brought to the power, and unless the means of approach are easy it will nevertheless be located elsewhere and run by steam. It is not possible to illustrate this point by figures, because the conditions are so complicated, and because steam-power, as well as water-power, is largely dependent upon means of transportation.

Again, where fuel is cheap the value of water-power is correspondingly lessened; and consequently throughout the coal regions of this country there is not only an excess of steam- over water-power, but the amount of the latter per square mile is much smaller than would otherwise be the case.

Further, there are some industries for which water-power is better adapted than steam-power, either on account of the greater cleanliness connected with its use, or because the manufacture requires the use of large quantities of water, so that such mills, even were they to use steam-power, would perhaps seek a location on the banks of some stream. Thus the table on page xvi shows that, of the industries specified, the largest proportion of water-power is found in the case of paper-mills, 70.70 per cent. of their total power being water-power. These mills require large quantities of clear water for purposes of the manufacture, and the large proportion thus finds a simple explanation. Again, of the total power used in flour- and grist-mills, 60.94 per cent. is water-power, being a larger proportion than in any industry except the one just referred to. This finds its explanation in the fact that very many of these mills are small and for local use only, so that with them the question of transportation loses its importance, and water-power, on account of its cheapness, is preferred. In the case of cotton-, worsted-, and woolen-mills, which use considerable quantities of water for washing, the proportion of water-power is still above the average for the entire country. On the other hand, the proportion of water-power used in the manufacture of boots and shoes, and of iron and steel, is insignificant. In the former case this is explained by conditions of location, by the very small average amount of power per establishment, and by the smaller use of water for purposes of manufacture. In the case of iron and steel, the manufacture is not dependent upon water to any great extent; and although the average amount of power per establishment is large, it is especially questions of location and easy transportation which render the proportion of water-power so small.

It is interesting to compare the proportion of water-power in the case of iron and steel with that in the case of foundery and machine-shop products. The larger proportion in the latter case finds its explanation in the local character of many of the establishments, and their dependence to a smaller extent upon location and convenient means of transportation.

The table shows that the industry consuming the largest amount of power is the manufacture of flouring- and grist-mill products, with 38.35 per cent. of the total power of the country. Next comes lumber, sawed, with 22.74 per cent., and then cotton goods and paper, with 12.14 and 7.15 per cent., respectively.

In the special reports comprised within these volumes the conditions affecting water-power in different sections of the country have been clearly set forth, and comparisons have been drawn between the streams of different

regions as regards their general character and their adaptability for utilization. A brief glance may here be cast, however, over the water-power of the country as a whole, and some comparisons made which will perhaps render more clearly apparent the differences between its different parts.

As regards water-power, the principal points to be kept in view in considering a region are its topography and geology, and the volume of its streams. Confining our attention for the present to the Atlantic and eastern Gulf slopes of the United States, we have to consider the region stretching from the Atlantic and the Gulf westward or northward to the dividing-line or water-shed, lying somewhere within the great Appalachian Mountain system, and separating the waters flowing directly to the ocean or the Gulf from those flowing west or north to the Mississippi or Saint Lawrence basins. The mountain system in which this water-shed lies reaches in Maine a height of 1,500 or 2,000 feet, with one peak at 5,200 feet, and it attains in New Hampshire its northern culminating point in the White mountains, many of whose peaks rise above 5,000 feet. Descending, as we follow the system southward, it reaches its lowest point in New York, the valley of the Hudson and Mohawk rivers leading to the lowest crossing between the Atlantic and the basin of the great lakes, at an elevation of only 430 feet. Continuing southward, through New Jersey, Pennsylvania, and Virginia, the Appalachian system again increases in elevation, and in North Carolina it attains a second and higher culminating point, scores of peaks towering to over 6,000 feet. From this point southward, through South Carolina, Georgia, and Alabama, the system falls again, and gradually shades off into the comparatively low divide between the waters of the Gulf and those flowing into the Mississippi and Tennessee rivers. This great system of mountains, then, itself composed in great part of a series of nearly parallel chains, between which lie narrow and parallel valleys, overlooks on one side the great Atlantic plain extending eastward to the sea, and on the other the elevated table-land which forms its base on the west, and which falls gradually to the prairies of the central states. This western plateau has a comparatively uniform height of about 1,000 feet, while that of the base of the mountains on the east, starting almost from the sea-level at the mouth of the Hudson, rapidly increases both toward the north and the south, rising to from 300 to 500 feet in New England, to from 100 to 300 feet in Pennsylvania, 500 in southern Virginia, and from 1,000 to 1,200 in southern North Carolina. At the same time, the width of the Atlantic plain, from the base of the mountains to the sea, gradually increases north and south from almost nothing at the mouth of the Hudson to about 50 miles in New England, over 200 in the southern Atlantic states, and to a still greater width along the Gulf. The water-shed or divide between the Atlantic streams and those to the west and north, however, which, from almost the extreme south up as far as into North Carolina, follows the extreme eastern ridge or chain of the mountains, bends gradually to the west, completely crossing the system, until in New York it is found on the plateau forming its western base. Topographically, then, the principal distinction to be drawn on the Atlantic slope is that the streams south of Virginia take their rise and complete their course entirely on the eastern flank of the Alleghanies, while from North Carolina to New York they gradually penetrate farther and farther into the mountains, until the sources of the Susquehanna, Delaware, and Hudson are found quite on the other side of the system, on the western plateau, from which they cut through the entire system to reach the sea. In New England the mountains are more detached and isolated than in the south, but the water-shed line runs in general along their western flank.

The Atlantic plain proper may be divided into two quite distinct portions by a line passing through Columbus and Augusta, Georgia, and running northward or northeastward, leaving between itself and the coast a gradually narrowing plain, until it reaches the sea at the mouth of the Hudson, whence it follows the coast quite through New England. Speaking generally, the region between this line and the sea, comprising a quite level section, narrowing from a width of nearly 150 miles in the extreme south to almost nothing in New York, is of recent geological formation, belonging chiefly to the Tertiary and post-Tertiary periods; while the entire region west and north of this line is geologically older. In New England it is occupied almost entirely by metamorphic rocks, and south of Pennsylvania these predominate, while in the middle states—New York, Pennsylvania, and Maryland—the rocks are principally of more recent date. To this last region belongs, therefore, almost the whole of New England and much the greater portion of the middle states, while in the extreme south the eastern region is of very large area. In this eastern region, which, as we have seen, reaches its greatest width in the south, the rivers are tortuous and sluggish, running through swamps, obstructed by sand-bars, snags, or fallen trees, but navigable or capable of being made so. The natural limit of navigation is in fact the limit of the eastern region, and along the line which has been described, and which we may call the *fall-line*, the rivers pour down generally with a considerable fall in a short distance, descending from the more elevated region west or north of the fall-line to the lower eastern region or to the sea. If we understand by *middle region* the region between the base of the mountains and the fall-line, we may briefly, but rather elliptically, describe the topography of the streams by saying that in the south they are confined to the middle and eastern regions, the mountain region being small, while toward the north they drain a gradually increasing mountain region, the middle and eastern regions diminishing until in New York and New England there is no eastern region whatever.

In the eastern region the streams are evidently of no value for water-power; in the mountain region or near their sources they are often equally valueless; hence, to compare their slopes, we should compare only those portions principally in the middle and western regions, where the economical development of power is possible, if anywhere.

The following table is therefore of interest, and it shows that on the whole the slope of the streams is pretty much the same from the Chattahoochee to the Merrimack. Only the streams of Maine and the Hudson stand prominent with a remarkably large slope in what may be called their *working* portions. Thus the middle and northern streams make up, by a greater penetration into the mountain region, for the smaller elevation of the western limit of the Atlantic plain proper.

Slope of the principal streams flowing into the Atlantic and the eastern Gulf.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.
			Miles.	*Feet.*	*Feet.*
Saint Croix	Chiputneticook lake	Tide	55	383	7.0
Penobscot	Source	do	173	1,509	8.7
Kennebec	Moosehead lake	do	112	1,023	9.1
Androscoggin	Rangeley lake	do	180	1,511	8.4
Saco	Conway, New Hampshire	do	73	412	5.6
Merrimack	Lake Winnipiseogee	do	124	500	4.0
Connecticut	West Stewartstown	do	294	1,035	3.5
Connecticut	Source	do	325	2,038	6.3
Hudson	North River village	do	102.5	1,039	10.1
Mohawk	Rome, New York	Mouth	115	418	3.6
Delaware	Deposit, New York	Tide	212	984	4.6
Susquehanna	Source	do	422	1,193	2.8
Potomac	Cumberland, Maryland	do	185	610	3.3
James	Clifton Forge, Virginia	do	225	1,014	4.5
Roanoke	Danbury ford (on the Dan river)	Head of navigation	208	651	3.1
Cape Fear	Haw River (on Haw river)	Foot of Smiley's falls	110	605	5.5
Yadkin	Patterson, North Carolina	Fall-line	241	1,145	4.8
Catawba	Old Fort, North Carolina	do	318	1,430	4.5
Congaree	Green River (on Broad river)	do	143	629	4.4
Oconee	Near Lula, Georgia	do	145	984	6.8
Chattahoochee	Near Gainesville, Georgia	do	215	751	3.5

In New England, and especially in Maine, the coast is abrupt, and the water deep immediately off shore. The harbors in this region are consequently excellent. In the middle and southern Atlantic states the gradual slope of the eastern division continues beyond the coast, and deep water is reached only at some distance. The harbors are here not so good as in New England.

The predominance of the metamorphic rocks in New England gives rise to a greater number of concentrated falls than anywhere else on the Atlantic slope. In the southern states abrupt falls are less frequent, although they often occur, especially on the smaller streams; but the falls of the large rivers are for the most part in the shape of long shoals or rapids, sometimes extending over a number of miles, the bed being gravel or bowlders. In the middle states, owing partly to the topography and partly to the softer character of the rocks, the slopes are for the most part gradual, and abrupt falls are, as a rule, rare. An inspection of the table on pages xxxiii and xxxiv will reveal this fact very clearly. In this respect, then, the more southern streams, and especially those of the middle states, are at a disadvantage, particularly as their width at these shoals is often very large. While, therefore, the table on pages xxxiii and xxxiv contains mention of a number of large powers on these streams, the expense of utilizing many of them would be so large that it will scarcely be attempted, requiring, as it would in many cases, very long and expensive dams and long canals. Among the larger streams, the Susquehanna river is prominent by reason of the fact that it offers not a single large utilized power, and very little power economically available, by reason of its uniform slope and great width.

Considering, now, the volume of water carried by the streams in question, it is clearly shown in this volume that as we proceed southward from New England the streams become in general more variable in flow, the freshets more violent, and the low-season flow smaller. These results are due to three principal causes: In the first place, the streams south of the Delaware are not regulated in flow by any large lakes, such as are so abundant in New England. In fact, south of the Susquehanna there is not a lake in the region considered, except one or two near the coast, where they are of no value in this connection. Moreover, the streams are not regulated by artificial storage reservoirs, as is the case so largely in New England, and, in fact, the topography of the river valleys is often such as to preclude any very extensive works of this nature. The result of this is that, while in New England the ordinary low-water flow of many of the smaller streams is in many cases doubled or even trebled by supplies drawn from storage reservoirs alone, this is not the case south of the Delaware to any appreciable extent. In the second place, the topography of the drainage basins of many of the streams in the middle and southern states explains in a measure their more variable flow. In the third place, the rainfall in New England and in parts of the middle states is distributed with a greater quantity in summer and autumn than in winter and spring, thus giving an increased supply to meet the draughts of evaporation in the summer months, while in the states south of Pennsylvania or Maryland the reverse is true, thus tending to render the streams more variable.

The southern streams, though free from the dangerous ice-freshets which sometimes occur in the north, are nevertheless subject in places to rises far exceeding any thing on record in New England. The following table shows the maximum recorded rise above low water of various streams on the Atlantic coast, and indicates to a certain extent the increasing variability toward the south; but it must be observed that this is by no means an accurate criterion from which to judge of the uniformity of flow of a stream, and that the rise depends upon so many circumstances—such as shape of the valley at the point in question, slope of the stream, width, etc.—that no certain inferences could be drawn from such data, and that of two streams the one really more constant in flow might reasonably exhibit a larger rise in freshets at a certain point than was ever reached anywhere on the other. Nevertheless, the liability of a stream to excessive rises is a very important factor in determining its value as a source of power, and in this respect the advantage must be conceded to the streams of the North. The reason of the large rises recorded on many of the southern rivers is probably to be found in the absence of lakes, in the liability to sudden and excessive falls of rain upon the elevated or mountainous regions, which discharge it at once into the water-courses, and in the small slope of the eastern or navigable portion of these streams, at the junction of which with the middle region the heaviest rises occur.

River and place.	Maximum recorded rise.	River and place.	Maximum recorded rise.
Kennebec at Augusta, Maine	25±	James at Richmond, Virginia	28.9
Merrimack at Lawrence, Massachusetts	26.5	Shenandoah at junction of forks	40+(?)
Connecticut at Hartford, Connecticut	29.8	Roanoke at Weldon, North Carolina	50
Hudson at Troy dam	22.0	Dan at Madison, North Carolina	28.4
Mohawk at Lower aqueduct	28.5	Cape Fear at Fayetteville, North Carolina	65(?)
Delaware at Easton, Pennsylvania	42.0	Yadkin at Wilksborough, North Carolina	23
Schuylkill at Fairmount dam	11.4	Savannah at Petersburg, Georgia	44
Chemung at Elmira, New York	24.0	Coosa at Wetumpka, Alabama	54
		Chattahoochee at Columbus, Georgia	42
		Chattahoochee, at Atlantic and West Point railroad	25.6

The table on pages xxviii and xxix, containing a compilation of all the principal data regarding flow which are scattered through these reports, will bear still stronger evidence to the fact that the northern streams are much more uniform in flow than those to the south. As regards absolute volume, the larger streams of the Atlantic slope discharge annually, according to varying conditions, from 25 to 60 per cent. of the rainfall over their basins, which itself varies in different localities from 38 to 56 inches.

Finally, as regards the question of accessibility, the streams of the northern and middle states have a great advantage in this respect, being generally more easy of access by rail than the streams farther south, where the topography often renders the location of a railroad most favorable along the divides; while, as regards water communication, the close proximity in the North of the lowest falls to tide-water and to the coast is an important advantage in comparison with the long stretch of tortuous and shifting channel which in the South separates the fall-line from the sea. Thus the head of navigation on the Alabama river is over 300 miles from the Gulf, and other southern streams have even longer navigable portions, while in New England navigation on the rivers is not carried over 50 miles from the coast, and rarely that.

Considering all these circumstances, it must be allowed that on the Atlantic slope the streams of New England are in all respects the most favorable for water-power; and of the New England streams few will compare with the great rivers of Maine. One can not read the list of splendid powers in that state, many still lying idle, without becoming convinced that her water-power is unsurpassed. Her lakes, many of them lying at a higher elevation than that of lake Itasca, the source of the Mississippi, or than lake Superior; her rivers, plunging over ledge after ledge of unyielding granite in their short courses from these reservoirs to the sea; her extensive woods, adding their regulating effect to that of the lakes; and her navigable bays and inlets, reaching to the last great leap of the rivers—all these constitute an array of favorable circumstances which, in spite of some opposing disadvantages, would be difficult to equal.

Crossing, now, the Alleghanies, and considering the great central basin of the continent, many of the streams present a marked contrast to those which have just been considered. Stretching from the western base of the Alleghanies to the eastern base of the Rocky mountains, a distance of from 1,200 to 1,500 miles, this immense region descends from east and west toward the Mississippi, while on the north and northeast a considerable region finds its outlet in the tributaries of the great lakes and the Saint Lawrence and of Hudson's bay.

The streams flowing into lake Ontario, descending within a short distance from the elevated plateau of New York and Pennsylvania to the comparatively low-lying lake, have a rapid fall, and offer many shoals and rapids and not a few cataracts; but the latter are not so numerous as would be expected, owing to the presence throughout the region of comparatively soft and disintegrable rocks. Flowing over these, the streams have gradually obliterated many falls which once existed, until they now flow in the gorges they have hollowed out for themselves, while the falls which still remain are gradually receding as this universal leveling tendency continues. The divide

or water-shed line between these streams and those flowing directly to the sea rises from an elevation of but 430 feet near the head-waters of the Mohawk, to 2,000 feet or more in some parts of Pennsylvania and in the Adirondacks, and the average slope of the principal streams is at least 10 feet per mile. The rainfall being greatest in summer and autumn, and there being numerous lakes in the region, the streams are as a rule well sustained, and will compare favorably as regards power with the streams of the Atlantic slope and even of New England.

Mention may here be made also of the Niagara, the mighty stream through which the accumulated waters of the enormous system of the great lakes seek their outlet, and which, in its short course of 37 miles, falls through a height of 333 feet, developing the enormous total of over 6 million horse-power, or more than five times the total amount of water-power in use in the United States in 1880. The precipice over which the principal part of the descent is made corresponds to that which occasions falls on some of the streams to the east, and, like them, it is gradually receding as the comparatively soft rocks are disintegrated. This mighty power, unrivaled as regards constancy and amount, stands apart among the powers of the country, and the detailed report concerning it must be read if even a faint conception of its features is to be gained, while it must be seen to be fully appreciated.

Farther to the west, much the greater part of the country east of the Mississippi is drained by the tributaries of the Ohio, and of these the southern tributaries, and also the two head-waters, the Allegheny and Monongahela, are very different in character from the northern ones. The former, descending rapidly from the elevated plateau or the great valley forming the base of the mountains, and which rises from an elevation of 1,500 feet in Pennsylvania to 2,600 feet at the head-waters of the New river, in North Carolina, again to fall to 1,000 feet along the upper Tennessee—descending from this elevated region very rapidly for a few miles, the southern tributaries of the Ohio soon reach the eastern border of the great central plain which stretches with a small and almost uniform slope westward to the Mississippi, and in their middle and lower portions they flow toward the west and north with a very small slope, and are navigable for long distances. Thus the Ohio itself is navigable for its entire length, while of its head-waters, the Allegheny is navigable for small steamers during about half the year to a point 123 miles above Pittsburgh, and the Monongahela is also navigable by means of locks and dams for over 100 miles. Similarly, the Cumberland is navigable for 550 miles during several months of the year, the Tennessee for 453 miles, barring one shoal, and the Green river for 175 miles. It is thus evident that none of these streams offer any facilities for water-power in their lower portions. Above the head of navigation they no doubt afford a large amount of power, but their flow is so variable and the country they drain is so wild, inaccessible, and little developed, that even here their power is of no value, and scarcely any of it is utilized. They are regulated by no lakes, and the country they drain is steep and favorable to a rapid discharge of the rainfall; the latter, too, is distributed in a way unfavorable to a uniform flow, and the result is that they are subject to heavy freshets and to severe droughts, impairing very much the value of whatever power they possess.(a) The following table shows the slope of some of these streams on their lower portions:

Slope of some of the southern tributaries of the Ohio.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.	Remarks.
			Miles.	*Feet.*	*Feet.*	
Cumberland	Nashville, Tennessee	Mouth	192	79	0.41	Navigable during six months for steamers of 300 tons.
Green	Bowling Green, Tennessee	...do	175	60	0.34	Navigable by locks and dams.
Kentucky	Mouth of Middle Fork	...do	258	228	0.88	Navigable by locks and dams for 95 miles above mouth.
Licking	West Liberty, Tennessee	...do	231	310	1.34	
Great Kanawha		...do	89	86	0.96	
Little Kanawha	Bulltown, West Virginia	...do	131	200	1.53	
Monongahela	Mouth of West Fork	...do	123	132	1.07	Navigable by locks and dams for 102 miles.
Allegheny	Olean, New York	...do	255	725	2.84	

Like so many of the streams in the middle and southern Atlantic states, the falls in these streams below their extreme head-waters are generally in the shape of long shoals. Thus the fall at the principal shoals on the Cumberland is 55 feet in 8 miles; on the Tennessee, 164 feet in 36.5 miles; and likewise on the Allegheny, 11.23 feet in 6,900 feet. As an example, however, of the rapidity with which these streams descend from their elevated sources to the plateau or gentle slope in which their subsequent courses lie, Mr. Porter mentions the fact that the Cheat river, in West Virginia, descends 2,400 feet in the last 80 miles of its course to the Monongahela, while the latter falls but 75 feet in the 90 miles from the mouth of the Cheat to Pittsburgh.

The northern tributaries of the Ohio are somewhat different in character. The divide between the basin of the Ohio and that of the great lakes lies everywhere at a comparatively small elevation, from which the streams descend in both directions, flowing through an only gently undulating country and with comparatively small slopes. To quote from Mr. Porter's report on these tributaries of the Ohio: "They are already largely in use and will admit of much further development. The powers offered, though well suited to the demands of ordinary manufacturing, are not, individually, of great magnitude, for the reason that the fall at command on the principal streams is nowhere

a Thus the Little Kanawha is said to have risen 28 feet within 24 hours.

very large, while their flow is on a rather small scale relatively to the extent of area drained, and in the dry season sinks very low; so that, if their value is to be estimated on the basis of permanently reliable power, they can not take a high rank. There are probably no privileges on the northern tributaries of the Ohio which can be depended upon at all times for more than 1,000 or 1,500 effective horse-power, and even such are of unusual occurrence."

The following table shows the slope of some of these streams in their lower portions. It will be noticed that the slope is considerably greater than that of the southern tributaries of the Ohio in their corresponding portions, and, in fact, these northern streams are in almost every way better suited for the development of power:

Slope of some of the northern tributaries of the Ohio.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.	Remarks.
			Miles.	*Feet.*	*Feet.*	
Wabash	Mouth of Little river.	Mouth	370	385	1.0	Navigable for some distance.
Great Miami	Dayton	do	77	298	3.9	Extensively used for power.
Do	Piqua	do	108	422	3.9	
Scioto	Columbus	do	110	225	2.0	Not navigable.
Do	Green Camp	do	152	433	2.8	
Do	Extreme source	do	210	933	4.4	
Muskingum	Dresden	do	91	130	1.4	Navigable by locks and dams.
Do	Mouth of Walhonding river	do	151	367	2.4	

Flowing, like the southern tributaries, over a region of recent geological age as compared with New England and other parts of the Atlantic plain, the declivity of these streams is uniform and the bed principally gravel and sand. As regards their flow, the proportion of the rainfall discharged is small as compared with that in New England, Humphreys and Abbot estimating it at 24 per cent. for the entire Ohio basin. The deep soil, the permeable underlying strata, the openness of the country, and the absence of lakes and swamps, are reasons for this fact. And not only this, but the flow of the streams is much more variable from month to month than in the New England or middle Atlantic states. The rainfall throughout almost the entire Ohio basin is generally much less in autumn than in any other season, and less in summer and autumn than in winter and spring, especially in the southern portion of the basin. This fact, with the absence of lakes and the character of the country, explains the variable discharge, which a glance at the table on pages xxviii and xxix shows to exist. Mr. Porter states the principal disadvantages on the northern tributaries to be the liability to extreme low water in summer and autumn; the heavy freshets and ice-runs; the backwater, which often lasts for a considerable period; and the difficulty of obtaining rock foundations. The power is principally used for flouring- and grist-mills. As regards accessibility, however, these streams leave nothing to be desired.

As for the Ohio itself, its fall at low water from Pittsburgh to its mouth is 430 feet, the distance being 967 miles, and the slope, therefore, 0.44 foot per mile. It offers but one opportunity for the development of power—at Louisville, Kentucky—where the fall at low water is 26 feet in 2 miles, and around which a canal is constructed. The theoretically available power is enormous, but practically not all could be economically developed.

The streams flowing into lake Erie from the south, and those draining the peninsula of Michigan, resemble in general characteristics the northern tributaries of the Ohio. They offer but little power of importance, and no sites which would yield over 1,000 gross horse-power throughout the year. Their slopes are uniform and generally small, there being but one prominent instance in all this region of a large concentrated fall, namely, Cuyahoga falls, in eastern Ohio, where the river of the same name descends 194 feet in 2 miles. The small quantity of water, however, renders this otherwise excellent site of limited importance, the available power at ordinary low-water being not over 1,000 gross horse-power. The largest stream in all this region is the Maumee river, draining 6,723 square miles, but even this affords no power of over 500 horse-power.

The remarks which have been made regarding the northern tributaries of the Ohio will also apply in general to the smaller eastern tributaries of the Mississippi; but toward the head-waters of that river, in the Northwest, an essentially different condition of things exists. It may be said that between the Appalachian and the Rocky mountains there are no connected mountain ranges. There are, however, a few isolated ranges, and of these some are found along the shores of lake Superior. Approaching, then, the head-waters of the Mississippi, we come to a region lying at an elevation of from 600 to 1,600 feet above tide, and comprising some rough and even rugged country, where the slopes of the streams are large, and where their courses lie over beds of hard metamorphic rock. The most striking feature of this region, however, is the presence of great numbers of lakes, by which the flow of the streams is regulated to a large extent, although the lakes are shallow, and the evaporation from many of them is quite equal to the inflow. Moreover, throughout this region, comprising the basins of the western tributaries of lake Michigan, that of lake Superior, of the upper Mississippi, and part of that of the Red river of the North, the rainfall is distributed in a way very favorable for constancy of flow, very much more falling in summer than in any other season. The absolute amount of rainfall is small, varying from 35 inches in Michigan and around lake Superior to

25 inches on the upper Mississippi and Red rivers, but its favorable distribution and the large number of lakes (over 8,000 in the region referred to), together with the extensive woods in some portions of the region, and the character of the country, which generally is not very favorable to quick drainage, more than counterbalance this disadvantage, and render the water-power of some of these streams even comparable with that of New England.

Perhaps the most noticeable stream in this region is the Lower Fox river, the outlet of lake Winnebago, which in its course of 37½ miles from the lake to Green Bay falls a distance of 170 feet, affording twelve large powers, with an aggregate of over 46,000 horse-power at ordinary low water, of which but a small fraction is utilized. This stream, as regards fall, constancy, and general facilities for power, is quite on a par with the best streams of New England.

Of the other streams flowing into lake Michigan, the Milwaukee, Sheboygan, and Manitowoc on the south have slopes of about 8 feet per mile, and are used principally for flouring- and grist-mills. Being unregulated by lakes, their flow is quite variable. Toward the north, in the region of metamorphic rocks, occupying northern Wisconsin, Michigan, and Minnesota, the streams descend more rapidly, but are in a wild and inaccessible country. The Menominee, flowing southeast into lake Michigan from the range of hills which borders lake Superior on the south, offers an immense amount of power, almost entirely undeveloped. It falls 970 feet in 160 miles from its mouth, descending in rapids and cataracts over ledges of upturned rock; but, although its basin is heavily clothed with timber, there are few lakes to regulate its flow. Along the southern shore of lake Superior the water-shed lies at an elevation of from 600 to 1,050 feet above the lake, and at a distance from it of about 30 miles; and the streams draining this region must offer large amounts of power entirely undeveloped. The western and northern tributaries of the lake, however, have especially large falls, for on the north shore the water-shed is 1,000 feet or more above the lake and but 8 or 9 miles distant. The rock in this region is igneous and very hard, and the streams, though generally very short and carrying but small quantities of water, descend with plunge after plunge till they reach the lake. The Saint Louis river, which enters the lake at its western extremity, and drains over 3,000 square miles, merits particular mention on account of its descent of 456 feet in the last 11 miles of its course, giving rise to one of the most magnificent powers in the West, the available horse-power at ordinary low water being estimated by Mr. Greenleaf at nearly 50,000 horse-power. The rainfall over the region draining into lake Superior is from 30 to 35 inches, favorably distributed; and although there are few lakes on the basin of the Saint Louis river, Mr. Greenleaf estimates its ordinary low-water flow at 0.4 cubic foot per second per square mile, a flow which would do credit to many a New England stream.

To the west of the Mississippi the Red river of the North is a curiously different stream. Flowing northward from about the latitude of central Minnesota, the main stream is entirely a prairie stream, its course lying in a wide and nearly level valley, and its fall from Breckenridge to the national boundary, a distance of 394 miles, being but 165 feet, or an average of only 0.418 foot to the mile. There is much drift over all this region, and along this part of the river's course no rock is found in place. The bed is nothing but gravel and sand, and the declivity very uniform, the heaviest slope being at the rate of 1.6 foot per mile for a distance of nearly 3 miles. Above Breckenridge the stream descends from the hill country of central Minnesota, and its fall from Otter Tail lake to Breckenridge, a distance of 34 miles, is at the rate of nearly 11 feet per mile. From this hill country, which is at the same time dotted with lakes, come the eastern tributaries of the stream, upon which, as well as upon the main stream above Breckenridge, lies all the available power in the basin. Over this hill region the rainfall is about 25 inches, favorably distributed, and this, in connection with the numerous lakes, renders the flow of the streams so uniform that at Fergus Falls on the main river a rise of 4 feet is not often exceeded. The western tributaries of the river, however, drain a prairie region where there are very few lakes, and where the rainfall is but about 15 inches, with a very small amount in the autumn; and these circumstances, in connection with the open character of the country, the large evaporation, and the small fall of the streams, renders their flow very variable and their water-power of no value. The Red river thus possesses the curious characteristic that at the national boundary, where it drains over 3,900 square miles, its ordinary low-water flow is about 0.07 cubic foot per second per square mile, while at Breckenridge, where its drainage area measures only about 4,747 square miles, the ordinary low-water flow per square mile is 0.217 cubic foot per second. And while at the latter point its flow is remarkably uniform, in its lower course, on account of its altered character and its small declivity, as well as owing to climatic conditions, it is visited by tremendous floods.

While the slope northward into lake Superior is rapid, the slope southward into the upper Mississippi is much more gradual. Nevertheless, the upper Mississippi and its tributaries afford more power than is to be found anywhere lower down in its basin. From the extreme sources of the river to Saint Paul, a distance of about 500 miles by the river, the fall is about 1,000 feet, and some important powers exist, while at Minneapolis is found one of the grandest powers in the Northwest, the minimum theoretical power, during 24 hours, being stated at 25,000 horse-power. The large number of lakes, the favorable distribution of the rainfall, and the topography of the country, render the flow well sustained throughout the year, while the rocky character of the streams in many places affords good facilities for utilization. Below Saint Paul the main river offers but one power, and is for the most part a navigable stream, the great highway of the central basin of the continent.

The western tributaries of the Mississippi are for the most part prairie streams, and different in character from any hitherto considered. From the eastern base of the Rocky mountains—the elevated plateau of Montana, Wyoming, and Colorado—these prairies extend in an unbroken expanse eastward to the Missouri, rising again to the comparatively low divide separating that river from the Mississippi; while more to the south their hitherto unbroken monotony is varied by the range of the Ozark mountains, among which rise several of the lower tributaries of the Mississippi. The slope of the prairies is comparatively uniform, and varies from about 2 to 5 feet per mile; they are almost entirely without woods, but covered with a rich growth of grass. Their surface is rolling and sometimes hilly, and the streams flow in shallow basins, with low divides on either side. Geologically the country is of recent formation, and, although in some portions limestone and sandstone appear at the surface, by far the greater portion of the area is covered with a deposit of drift or loess. Below these lie the harder rocks, but the rivers have not cut their way down to them, and invariably flow in beds of mud, sand, quicksand, or gravel, with very uniform slopes and scarcely any rapids. There are thus no falls whatever on the real prairie streams, and the character of the bed and banks is very unfavorable for the development of power. There are, moreover, no lakes of importance in the region, and no advantages for artificial storage. Lying in the center of a great continent, the winds which reach this region have been almost drained of their moisture before reaching even its outer confines, and from 40.7 inches at Saint Louis, the mean annual rainfall diminishes as we proceed westward, until at Fort Bridger, in Wyoming, it is but 8.4 inches, while it is less than 20 inches at most points west of the 99th meridian. The rainfall in spring and summer is much greater than in autumn and winter, and the streams lose much by the excessive evaporation which takes place throughout the region. Thus, while in New England there are probably few streams which do not discharge annually from 30 to 50 per cent. of the rainfall which falls upon their basins, Humphreys and Abbot give a ratio of but 15 per cent. for the entire basin of the Missouri river. Although the rainfall is distributed in a measure favorable for a constant flow, yet the fact that the precipitation during the winter is almost entirely in the form of snow, which remains long upon the ground and is thus of little value to the streams, has the effect of carrying the streams very low during the late autumn and winter. Moreover, the pervious character of the soil, and the circumstance that the streams have not cut down to an impervious stratum, prevents much of the water which falls as rain from reaching the streams at all. In fact, during the dry season many streams dry up entirely, or are converted into a series of sluggish pools, while beneath, in the deep pervious subsoil, there may be a considerable percolation or seepage. The consequence is that the prairie streams, when at their lowest, discharge a remarkably small quantity of water in proportion to the extent of area drained. Thus, while the discharge of large streams on the Atlantic coast rarely falls below 0.2 cubic foot per second per square mile, even the largest prairie streams fall as low as from 0.05 to 0.10 at some time of the year; and even the Missouri river, draining over 500,000 square miles, has been known to offer as low a ratio as 0.05 or less.

The slope of many of these streams is quite rapid, as the table on page xxv shows, and owing to their generally considerable width they are not subject to extremely great rises in freshets, although rises of 30 and even of 40 feet have been known in some places.

The streams to which this description particularly applies comprise the Missouri and its tributaries, especially those from the west, draining the greater part of Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas, as well as Indian territory, drained by the Arkansas and Red rivers. In the mountainous parts of this region the streams, of course, have very steep slopes, and the bed is often rock; but they are still very variable in flow, and their principal use is for irrigation, after supplying the demands of which there is often little water remaining to be devoted to power. Those streams which flow in deep cañons, like some of those in Colorado, are, moreover, topographically unfitted for its development.

The power utilized on all these streams is insignificant in amount, and is principally used for flouring- and grist-mills. When the slope of the stream is sufficient, power may be equally well developed almost anywhere, there being no rapids. The dams, on account of the yielding character of the bed, are necessarily of brush in a great many cases.

Regarding the Missouri itself, it is navigable at some periods of the year to Fort Benton, in Montana, a distance of 2,644 miles. Thirty-five miles above this are the falls of the Missouri, where the stream descends 161 feet within a distance of 9 miles. There is no power, however, utilized from the river.

The tributaries of the Missouri from the east, draining portions of Dakota, Iowa, and Missouri, resemble in general the prairie streams from the west, their flow being quite as variable and their slopes even smaller. They flow generally over the loess formation, and their beds are generally muddy and their slopes uniform. In southern Dakota, on the Big Sioux river, is the only prominent instance of a sudden fall over a rock ledge to be found in the prairie region.

The following table shows the slope of some of the tributaries of the Missouri, to which are added for comparison that of some streams in the Northwest. It shows clearly that, so far as concerns fall, these prairie streams compare favorably, in many cases, with streams on the Atlantic coast, and even in New England; it is the absence of concentrated falls, the variable flow, the shifting bed, and the general unfavorable circumstances which render them far inferior as sources of power.

Slope of some tributaries of the Missouri river, and of some streams in the Northwest.

Stream.	Tributary to what.	From what state.	From—	To—	Distance.	Fall.	Slope per mile.
					Miles.	*Feet.*	*Feet.*
Missouri river	Mississippi river	Missouri	Fort Benton, Montana	Mouth	2, 644	2, 464	0. 93
Dakota river	Missouri river	Dakota	N. P. R. R. crossing	C. and N. W. R. R. crossing	252	157	0. 62
Big Sioux river	...do	...do	Watertown, Dakota	Mouth	221	639	2. 89
Little Sioux river	...do	Iowa	Cherokee, Iowa	Near mouth	79	101	1. 28
Boyer river	...do	...do	Near Denison, Iowa	Mouth	59	148	2. 51
Nishnabatona river	...do	Missouri	Near Atlantic, Iowa	...do	120	230	1. 92
Nodaway river	...do	...do	Near Villisca, Iowa	Near mouth	91	160	1. 76
Platte river of Missouri	...do	...do	Near Conception, Missouri	...do	119	321	2. 70
Grand river	...do	...do	Near Gentryville, Missouri	Mouth	128	181	1. 41
Chariton river	...do	...do	Chariton, Iowa	Near Keytesville, Missouri	186	403	2. 17
Niobrara river	...do	Nebraska	Near source	Mouth	355+	3, 829	10. 78
Platte river	...do	...do	North Platte, Nebraska	...do	304	1, 890	6. 22
Elkhorn river	Platte river	...do	Near O'Neill, Nebraska	Near mouth	201	858	4. 27
Loup river	...do	...do	Head of Middle Loup	...do	257	1, 796	7. 00
North Platte river	...do	...do	North Park, Colorado	North Platte	514	4, 836	9. 41
South Platte river	...do	...do	Denver, Colorado	Mouth	285	2, 454	8. 61
Kansas river	Missouri river	Kansas	Junction of forks	Near mouth	184	330	1. 79
Big Blue river	Kansas river	...do	Seward, Nebraska	...do	153	384	2. 51
Republican river	...do	...do	Western boundary of Nebraska	Mouth	423	2, 530	5. 98
Smoky Hill river	...do	...do	Wallace, Nebraska	...do	395	2, 275	5. 76
Osage river	Missouri river	Missouri	Ottawa, Kansas	...do	417	358	0. 86
Gasconade river	...do	...do	Indian Ford, Missouri	...do	78	108	1. 38
Milwaukee river	Lake Michigan	Wisconsin	Head-waters	...do	66	500	7. 58
Sheboygan river	...do	...do	...do	...do	45	360	8. 00
Manitowoc river	...do	...do	...do	...do	42	350	8. 33
Lower Fox river	...do	...do	Lake Winnebago	...do	37½	165	4. 40
Menominee river	...do	...do	Head-waters	...do	160	975	6. 09
Red river of the North	Hudson's bay	Minnesota and Dakota	Otter Tail lake	Breckenridge, Minnesota	34	368	10. 82
Do	...do	...do	Breckenridge, Minnesota	National boundary	394	165	0. 42

The tributaries of the Mississippi from eastern Iowa offer a marked contrast to those draining the western slope. Not only is their fall very much larger, but numerous rock exposures occur along the streams, and rapids occasionally occur. The drift deposits are thick over this region, while the loess which covers so much of the western slope is almost absent here. Moreover, the streams are well sustained during the low season, by reason of the numerous springs issuing from the drift deposits, while farther west the loess is entirely lacking in springs. The rainfall is also greater here, averaging from 30 to 35 inches for the year, of which the summer yields the largest quantity, while spring and autumn come next, and are nearly equal, whereas farther west considerably more falls in spring than in autumn. The result of these circumstances is a much more uniform flow than is found in the streams farther west. Mr. Porter, in estimating the flow of these streams, assumes the low-water flow in an ordinarily dry year as from 0.06 to 0.09 cubic foot per second per square mile, while for the streams on the western slope he takes generally 0.04 or 0.05, though sometimes as high as 0.08, and for the prairie streams west of the Missouri he uses a smaller ratio still. These rivers are not navigable, and much power is utilized upon them, although a large amount is still available. The principal use of the power is for flouring- and grist-mills. There are, however, no individually large powers in eastern Iowa, probably none which will yield over 1,200 or 1,300 gross horse-power in low water of ordinarily dry years. The general slope of the country is at the rate of about 4.5 feet per mile toward the southeast, but the declivity of the individual streams is given in the following table:

Slope of the streams of eastern Iowa.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.
			Miles.	*Feet.*	*Feet.*
Maquoketa river	Manchester, Iowa	Mouth	87	333	3. 83
Wapsipinicon river.	Independence, Iowa	...do	135	328	2. 43
Iowa river	Near Iowa Falls	...do	215	485	2. 26
Cedar river	Cedar Falls, Iowa	Mouth of Iowa river	176	323	1. 84
Skunk river	Southeast part Hamilton county, Iowa	Mouth	203	551	2. 71
Des Moines river	Windom, Minnesota	...do	411	853	2. 08

But little need be said regarding the remaining tributaries of the Mississippi from the west. Those draining eastern Missouri, both those flowing into the Mississippi directly and those joining the Missouri, are practically of no value for power. In their lower parts they are sluggish and unsupplied with springs, and sometimes run entirely

dry. Some of them have their sources in the comparatively elevated region about the Ozark range, and in their upper parts are well sustained in flow, and fall rapidly over rocky beds, but the powers afforded are all very small.

The basin of the Arkansas river is in many respects similar to that of the Missouri. The mountainous portion, in Colorado, is similar to that of the Platte river, and doubtless power could be obtained there if it were wanted; but the streams are already more or less devoted to purposes of irrigation, and will probably soon be further used in this way, so that the subject of power is of comparatively small importance. In the prairie region the streams are very variable, being lowest in winter, and running dry nearly every year. Their slopes are uniform, their beds gravel, sand, or mud, and they are bordered by bottom-lands often several miles wide. Even the Arkansas runs almost dry at times, and near its mouth, where its drainage area is 160,000 square miles, its ordinary low-water discharge is but 0.019 cubic foot per second per square mile. The absence of facilities for storage, and the fact that more rain falls in summer than in any other season, while the precipitation in the autumn and winter is very small, together with the topography of the country, suffice to explain these facts. On the main river power is utilized at only two or three places and in but small amounts. In the upper 120 miles of its course, the river is a mountain torrent, and its slope is nearly 40 feet per mile. Eastward from the base of the mountains the prairies slope at the rate of about 8 feet per mile for 500 or 600 miles, and the declivity of the stream becomes gradually smaller as it nears its mouth, where it is at the rate of but 0.46 foot per mile for 150 miles. The principal utilization of power in the basin is in the middle country, in southeastern Kansas, where the streams can be dammed almost anywhere.

The Red river, the last important tributary of the Mississippi, is navigable for 460 miles, and is muddy and sluggish for a much greater distance. Near its head-waters it flows in a cañon, shut in by sandstone cliffs rising almost vertically for from 500 to 800 feet, while its fall is rapid over a sandy bed. Little power is utilized in its basin, and many of its tributaries from Louisiana and Arkansas, although in their upper parts they have a rapid fall over gravelly beds, go almost dry in the low season.

The following tables show the slope of some of the lower tributaries of the Mississippi, and the maximum recorded rise in freshets of some streams in the Mississippi basin and the Northwest:

Slope of some of the lower tributaries of the Mississippi.

River.	Tributary to what.	From—	To—	Distance.	Fall.	Fall per mile.
				Miles.	*Feet.*	*Feet.*
Meramec river	Mississippi river	Head spring	Mouth	172.5	390.5	2.26
Saint Francis	...do	Head-waters	...do	438.0	1,006.0	2.30
Do	...do	Eastern boundary Butler county, Missouri.	...do	308.0	170.0	0.55
Arkansas	...do	Source	Pueblo, Colorado	155.0	5,287.0	34.11
Do	...do	Pueblo, Colorado	Fort Gibson, Indian territory	812.0	4,208.0	5.18
Do	...do	Fort Gibson, Indian territory	Mouth	642.0	398.0	0.62
Red	...do	Source	Missouri, Kansas, and Texas Railroad crossing.	504.0	1,919.0	5.19
Do	...do	Missouri, Kansas, and Texas Railroad crossing.	Mouth	1,025.0	517.0	0.50
White	Arkansas river	Head of West fork	Forsyth, Missouri	257.0	1,333.0	5.18
Do	...do	Forsyth, Missouri	Mouth	590.0	458.0	0.77

Maximum recorded rise of various streams of the Mississippi basin and the Northwest.

River.	Locality.	Rise above low water.	River.	Locality.	Rise above low water.
		Feet.			*Feet.*
Ohio river	Mouth	50+	Gasconade river	Mouth	20–25
Do	Louisville, Kentucky	64	Des Moines river	In lower parts	25
Do	Cincinnati, Ohio	71	Arkansas river	Near mouth	[illegible]
Missouri river	Mouth	35	Do	Little Rock, Arkansas	33
Do	Saint Joseph, Missouri	20	Do	Wichita, Kansas	7½
Do	Fort Benton, Montana	6	Red river of the North	Breckenridge, Minnesota	16
Kansas river	Topeka, Kansas	30	Do	Moorhead, Minnesota	28
Smoky Hill river	Ellsworth, Kansas	20–23	Do	Below Moorhead	40
Osage river	Mouth	39	Red Lake river	Crookstown, Minnesota	20

The water-power of the region west of the Mississippi tributaries has not been included in the investigations of which the results are now presented, and little can here be said regarding it. In the plateau region of the Rocky mountains—a region of table-lands and cañons—there is probably little opportunity for the development of power, while in the Great Basin region, which follows it on the west, there are few living streams. On the Pacific coast the streams descend very rapidly from the Sierra Nevada and the Coast ranges, and their slope is very

large. Even the larger streams are navigable for but very short distances. The rainfall, however, is exceedingly variable in this region, frequently not a drop of rain falling during the summer in some parts of California, while the average summer rainfall over the greater part of the state is less than 1 inch; although farther north, in Oregon and Washington territory, summer rains and thunder-showers sometimes occur. The result of this is that, particularly in California, only the streams which head far up in the Sierras and are fed during the summer by melting snows and perennial springs, are sustained during the summer time. The streams which head in the foot-hills or in the Coast range of California are mostly dry during the summer, and even the larger streams, heading far up in the mountains, are very variable. There is no doubt, however, that these streams offer an enormous amount of power, little of which has been utilized.

The following table contains a summary of data regarding flow of streams, compiled from the data presented in these reports. It serves to bring out very clearly the difference between the streams in different parts of the country. It will be seen that of the large New England streams none fall as low in discharge as 0.2 cubic foot per second per square mile; while the Potomac, larger than any stream in New England in point of area drained, falls to half that amount, and the western streams, even those of large size, fall to lower figures still:

Summary of data

	Stream.	Locality.	Drainage area.	Mean rainfall. Spring.	Summer.	Autumn.	Winter.	Year.	Extremes of flow. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.
			Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*			
1	Merrimack river	Lawrence, Massachusetts	4, 599	10	11	13	9	43	96, 000	1, 400	69
2	Do	Lowell, Massachusetts	4, 085	10	11	13	9	43	81, 000	1, 275	64
3	Concord river	....do	361	11	11	12	10	44	4, 449	60	74
4	Hale's brook	....do	24	11	11	12	10	44	....	3. 25	......
5	Sudbury river	Framingham, Massachusetts	78	11	11	12	10	44	3, 228	2. 8	1, 153
6	Charles river	Newton Upper Falls, Massachusetts	215	11	11	12	10	44	....	44	......
7	Connecticut river	Hanover, New Hampshire	3, 316	10	12	12	10	44	....	1, 006	......
8	Do	Hartford, Connecticut	10, 154	10	12	12	10	44	205, 464	5, 208	40
9	Housatonic river	Kent, Connecticut	758	12	12	12	10	46	....	260	......
10	Do	Birmingham, Connecticut	1, 562	12	12	12	10	46	....	500	......
11	Croton river	....	339	12	13	13	10	48	25, 380	60	423
12	West branch Croton river	....	20. 37	12	13	13	10	48	1, 109	0. 33	3, 327
13	Hudson river	Palmer Falls, New York	2, 650	9	11	10	8	38	....	....	......
14	Mohawk river	Cohoes, New York	3, 490	9	10	10	8	37	....	800–1, 000	......
15	Oswego river	Oswego, New York	5, 013	8	10	9½	7	34½	4, 100	1, 153	36
16	Genesee river	Rochester, New York	2, 474	8	9½	9	7	33½	....	300	......
17	Passaic river	Paterson, New Jersey	813	12	14	12	10	48	17, 913	195	92
18	Raritan river	Near New Brunswick, New Jersey	825	12	14	12	10	48	....	180	......
19	Delaware river	Lambertville, New Jersey	6, 820	11	13	11	9	44	350, 000	2, 000	175
20	Schuylkill river	Philadelphia, Pennsylvania	1, 912	12	14	10	9	45	....	310	......
21	Potomac river	Cumberland, Maryland	920	10	12	9	8	39	17, 900	25	716
22	Do	Dam No. 5, Maryland	5, 066	11	13	9	8	42	92, 772	363	255
23	Do	Great Falls, Maryland	11, 476	12	13	9	8	42	175, 000	1, 063	165
24	Rock creek	Hoyle's Mill, District of Columbia	64. 4	11	12	11	8	42	9, 800+	7. 5	1, 307
25	Shenandoah river	Near Port Republic, Virginia	770	12	13	8	8	41	....	128	......
26	James river	Richmond, Virginia	6, 800	12	12	9	10	43	....	1, 300	......
27	Neuse river	Near Raleigh, North Carolina	1, 000	12	14	10	11	47	....	....	......
28	Alabama river	Near Montgomery, Alabama	16, 650	14½	13½	10½	15	53½	....	....	......
29	Tallapoosa river	Fort Decatur Bluffs	4, 040	14	13½	10½	14½	52½	....	....	......
30	Allegheny river	Roberts' Run ripple, Pennsylvania	6, 020	10	11	9	10	40	....	2, 070	......
31	Do	Near Pittsburgh, Pennsylvania	11, 100	10	12	9	10	41	....	1, 330	......
32	Ohio river	....do	18, 732	10	12	9	10	41	....	2, 271	......
33	French creek	Above Meadville, Pennsylvania	618	10	14½	9½	9	43	....	138	......
34	Kanawha river	Charleston pool, Virginia	8, 900	12	13	9	10	44	118, 291	1, 100	108
35	Greenbrier river	Mouth of Howard's creek	810	11	12	8	9	40	....	97	......
36	Scioto	Columbus, Ohio	1, 686	10	11½	8	8½	38	....	25	......
37	Lower Fox river	Foot of lake Winnebago	6, 046	9	12	9	5	35	....	2, 320	......
38	Red river of the North	Fergus Falls, Minnesota	1, 613	6	10	4	3	23	....	....	......
39	Do	National boundary	39, 577	5	8	3	2	18	....	....	......
40	Bois de Sioux river	Breckenridge, Minnesota	1, 996	5	8	3	3	19	....	....	......
41	Mississippi river	Grand Rapids, Minnesota	3, 636	7	12	6	3	28	....	....	......
42	Do	Aitkin, Minnesota	5, 715	7	12	6	3	28	....	....	......
43	Do	Wabasha, Minnesota	55, 876	6½	12	7	3	28½	....	....	......
44	Do	Rock Island, Illinois	87, 842	7	12	7½	3½	30	....	....	......
45	Do	Canton, Missouri	133, 995	7½	12	8	4	31½	....	....	......
46	Do	Hannibal, Missouri	137, 460	7½	12	8	4	31½	....	....	......
47	Wisconsin river	Portage, Wisconsin	8, 200	9	12	9	5	35	....	2, 800	......
48	Minnesota river	Foot of Big Stone lake, Minnesota	920	6½	12	5	3	26½	....	11	......
49	Do	Above Redwood river	8, 540	6½	11	5	3	25½	....	217	......
50	Do	Judson, Minnesota	11, 940	6½	11	5	3	25½	....	397	......
51	Do	Mouth	17, 230	6½	11	5½	3	26	....	1, 155	......
52	Illinois river	....do	29, 013	11½	11	9	8	39½	....	1, 600	......
53	Des Moines river	....do	14, 578	8½	13½	9	4	35	....	....	......
54	Cedar river	....do	7, 715	9½	13½	8½	4½	36	....	....	......
55	Missouri river	Saint Charles, Missouri	527, 000	6±	6±	4±	3±	19±	430, 000	15, 000	29
56	Gasconade river	Below Vienna, Missouri	3, 181	12	11	8	7	38	....	450	......
57	Kansas river	Topeka, Kansas	56, 354	8±	7±	6±	3±	24±	....	2, 000	......
58	Big Sioux river	Mouth	7, 880	6½	11	5½	3	26	....	....	......
59	Meramec river	... do	3, 914	11½	12	8	7	38½	....	600	......
60	Arkansas river	Arkansas City, Kansas	44, 500	3	9	3	2	17	....	675	......
61	Do	Mouth	160, 000	......	......	......	......	......	....	....	......
62	White river	Sixty-seven miles below Forsyth, Missouri	5, 511	13½	11	10	9	43½	....	264	......
63	Do	Mouth	27, 925	13½	11	10	9	43½	....	....	......
64	Ouachita river	Camden, Arkansas	5, 600	15	12	11	12	50	....	....	......
65	Do	Monroe, Louisiana	16, 050	17	12	11	14	54	....	....	......
66	Niagara river	Niagara Falls, New York	....	......	......	......	......	......	....	....	......

regarding flow of streams.

Minimum flow, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second.	Ordinary low-water flow, cubic feet per second per square mile.	Remarks and authority.	
0.30	2,800	0.60	Information given the writer for this report. Also *Transactions American Society Civil Engineers*, 1878, p. 241	1
0.31			Information given the writer for this report	2
0.17	126	0.35	C. Herschel. *Transactions American Society Civil Engineers*, 1878, p. 241	3
0.135			J. P. Frizell. See *Proceedings American Society Civil Engineers*, 1879, p. 110	4
0.036	12.5	0.16	*Transactions American Society Civil Engineers*, 1881	5
0.20			*Massachusetts State Board of Health.* Report for 1876	6
0.303	1,210	0.365	Professor Robert Fletcher	7
0.513			T. G. Ellis. Of late years the flow has been much lower	8
0.34			H. Loomis. *Report of New York Board of Public Works*, 1879	9
0.32			Measurements about 1867–1870	10
0.178			J. J. R. Croes. See *Proceedings American Society Civil Engineers*, 1879, p. 110	11
0.016			Do	12
	200–250	0.075–0.094	Mr. Warren Curtis (estimated)	13
0.23–0.28			D. H. Van Auken	14
0.23	1,500	0.30	Not gauged. *Supreme Court decree*	15
0.12			Statements regarding power, etc.; not a gauging	16
0.24			J. J. R. Croes and G. W. Howell	17
0.22			Ashbel Welch; gauging	18
0.29			Ashbel Welch. *Transactions American Society Civil Engineers*, 1881	19
0.16			H. P. M. Birkinbine	20
0.022			W. R. Hutton. *Transactions American Society Civil Engineers*, 1881, p. 242	21
0.078			Do	22
0.093			Do	23
0.114	29	0.455	Do	24
0.167			James Herron. *Seventeenth Report of Board of Public Works of Virginia*, 1832	25
0.191			H. D. Whitcomb	26
	193	0.193	W. C. Kerr; gauging	27
	3,711–	0.22–	Gauging by G. B. Yuille at a stage above ordinary low water	28
	1,420	0.35	Gauging at mean low water	29
0.34			Estimate from a gauging, by Mr. T. P. Roberts	30
0.12			"Said to be reached at times"	31
0.12			Gaugings, in 1879, by J. H. Harlow. See *Transactions American Society Civil Engineers*, 1881, p. 238	32
0.22			Gauging many years ago	33
0.123			W. R. Hutton. See *Transactions American Society Civil Engineers*, 1881, p. 242	34
0.12			Do	35
0.015			Gaugings in 1823–'24	36
0.38	2,500	0.413	Stated by United States Engineers. Stream is regulated by a large lake	37
	662	0.410	Authority not given	38
	2,800	0.070	Do	39
	50	0.025	Do	40
	969+	0.27+	Gauging at 0.4 foot below mean low water	41
	1,743+	0.305+	Gauging at 0.2 foot below mean low water	42
	10,000	0.179	Volume adopted for low-water discharge by government engineers	43
	19,000	0.216	Do	44
	26,000	0.194	Do	45
	30,000	0.218	Do	46
0.34			United States Engineers	47
0.012			*Report of Chief of Engineers*, 1875, Appendix J, p. 53	48
0.025			Do	49
0.033			Do	50
0.067			Do	51
0.055	1,750	0.060	Major G. J. Lydecker, United States Army	52
		0.090	Assumed by Mr. Porter in this volume	53
		0.119	Do	54
0.028			Assumed for ordinary extremes, based on gaugings	55
0.14		0.18	Minimum as given by T. J. Johnson; ordinary low water as assumed by Mr. Porter	56
0.035		0.043	Minimum during an extreme drought; ordinary low water as assumed by Mr. Porter	57
		0.025–0.027	Assumed by Mr. Porter in this report	58
0.15		0.18	Minimum as estimated by Mr. E. Schmidt, 1880; ordinary low water as taken by Mr. Porter	59
0.015			Measured by J. D. McKown	60
	3,000	0.019	Estimated by Major Suter, United States Army	61
0.048			Measured by A. Livermore	62
	3,000	0.1074	Estimated by Major Suter, United States Army	63
		0.063	Estimated	64
		0.037	Gauging, when river was 10 or 12 inches above low water, gave 0.050	65
			Average flow, 166,600 cubic feet per second, according to U. S. Engineers. Principal fluctuation is due to wind	66

The following tables contain a summary of information regarding the larger developed and undeveloped water-powers of the country, compiled from the different reports. It is not to be supposed, however, that every large power has been included. The line had to be drawn somewhere, and it was taken at about 2,000 horse-power, but it is quite possible that some powers have been omitted which are in many respects better than some which have been included. It is further to be remarked that the reports on the Mississippi river and some of its tributaries, not having been sent to press when this introduction was written, were not accessible to the writer, and the tables, as well as the general discussion, are in so far incomplete. Nevertheless a general idea will be obtained from the tables regarding the larger powers of the country, their importance, and their distribution. The table of developed powers shows that New England possesses at least ten developed powers of 10,000 theoretical horse-power or over during working-hours (although they are not all at present so developed as to be able to store the water at night), at least eighteen of over 3,000 horse-power continuously, and at about twenty of over 2,000 horse-power continuously. The basin of lake Ontario contains a dozen powers of large size, and a number exist in the middle states; but in the southern Atlantic and Gulf states there are but three, all of them large, however. West of the Alleghanies there is, with the exception of the comparatively small power at Lawrence, Kansas, not a single large developed power except in the Northwest. In the table of undeveloped power a large number of powers in the southern Atlantic states are included; but the remark on page xix must here be recalled, that on account of the comparative absence of abrupt falls on the larger streams in this region many of the powers so enumerated would admit of development only at a cost which would in many cases be perhaps almost prohibitory. It is again noticeable, however, that, excepting the powers in the Northwest, there is but one undeveloped power west of the Alleghanies of sufficient importance to be included in the table.

Large developed powers of the United States.

[NOTE.—Abbreviations in last column but one: **N. E.**, report on eastern New England; **L. I.**, report on the streams tributary to Long Island sound; **H. R.**, report on the Hudson River basin; **L. O.**, report on the streams tributary to lake Ontario; **M. A.**, report on the middle Atlantic water-shed; **S. A.**, report on the southern Atlantic water-shed; **E. G.**, report on the eastern Gulf slope; **N. W.**, report on the rivers of the Northwest; **M. R.**, report on the Missouri River basin; **N. R.**, report on the streams tributary to lakes Huron and Erie, and on the Niagara river.]

Locality.	Stream.	DAM. Length.	DAM. Average height.	Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.
Massachusetts.		*Feet.*	*Feet.*	*Feet.*		*Feet.*			
Lawrence	Merrimack river	900	32	30	Minimum is 11,000 during working hours.	26 to 30	Minimum is 10,909 gross.	N. E. p. 25.	Nearly all the permanently available power is utilized.
Lowell	do	1,093.5	10±	33	Minimum is about 11,845 during working hours.	33	Minimum is about 11,845 gross.	N. E. p. 30.	Do.
Holyoke	Connecticut river	1,017	35±	56	24,000	56	12,260 effective horse-power of wheels in use.	L. I. p. 51.	Power estimated for low water of ordinarily dry years, during 24 hours.
Turner's Falls	do	1,000	20 to 30	62.5	22,000	41	4,320 effective horse-power of wheels in use.	L. I. p. 56.	Do.
New Hampshire.									
Manchester	Merrimack river	680	11±	50	Minimum is about 12,000 during working hours.	50	Minimum is about 12,000 gross during working hours.	N. E. p. 35.	Minimum power is here calculated, assuming a slightly larger minimum flow per square mile than at Lowell, and allowing for its use during 11 hours.
Hooksett	do		3 to 4	14	Minimum probably at least 1,800 continuously.	14	Rated power of wheels about 350.	N. E. p. 38.	A fine site.
Garvin's Falls	do	550	8	28	Minimum probably at least 3,000 continuously.			N. E. p. 38.	A pulp-mill being erected in 1882.
Fisherville	Contoocook river	Several	Several	100	2,500 continuously in low season of ordinarily dry years.	100	Rated power of wheels about 1,000.	N. E. p. 47.	Power very wastefully used.
Franklin	Winnipiseogee river.	Several	Several	140	Minimum about 4,000 continuously.	105	Rated power of wheels about 2,500.	N. E. p. 31.	Flow controlled partially by corporations at Lowell and Lawrence.
Great Falls	Salmon Falls river	{ 375 / 140	6 / 24 }	55		55	Rated power of wheels about 2,500.	N. E. p. 66.	Full power of wheels can not be obtained at all times.
Maine.									
Biddeford and Saco	Saco river			40	1,700 continuously in low season of ordinarily dry years.	40	Rated power of wheels 4,600.	N. E. p. 72.	Do.
Brunswick	Androscoggin river.			55	9,000 continuously in low season of ordinarily dry years.	26 to 30	Rated power of wheels 1,500 to 2,000.	N. E. p. 79.	A fine site.

Large developed powers of the United States—Continued.

Locality.	Stream.	Dam. Length.	Dam. Average height.	Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.*			
Lisbon Falls	Androscoggin river.		10	33	5,300 continuously in low season of ordinarily dry years.	13	Rated power of wheels about 400.	N. E. p. 79.	A fine site.
Lewiston	...do		12	50	11,900 during 11 hours, minimum.	50	About 11,000 gross or theoretical.	N. E. p. 80.	
Livermore Falls	...do		7	14	3,000	29	Very small	N. E. p. 81.	Power estimated for low water of ordinarily dry years during 24 hours.
Jay Bridge Falls	...do			12	3,000	30	...do	N. E. p. 81.	Do.
Augusta	Kennebec river	956	17	17	3,500	17	About 900 effective	N. E. p. 86.	Do.
Waterville	...do	750	7	20	3,000	20	About 2,000 effective.	N. E. p. 87.	Do.
Kendall's Mills	...do			22	3,000		Probably small	N. E. p. 87.	Do.
Skowhegan	...do			28+	3,600		...do	N. E. p. 87.	Do.
Connecticut.									
Windsor Locks	Connecticut river	1,500±	3+	33	17,000	20 to 28	1,800 to 1,900 effective.	L. I. p. 48.	Do....But a small portion of the estimated available power of the river is practically commanded by present works.
Vermont.									
Bellows Falls	...do	600+		52 to 54.5	12,000	52	7,040 effective horse-power of wheels in use.	L. I. p. 58.	Do.
New York.									
Mechanicsville	Hudson river	795	16	20	2,040	16		H. R. p. 10.	Do...Being developed in 1882.
Glens Falls	...do	400	5½ to 6½	42		42	Total power in use about 2,000 effective horse-power.	H. R. p. 16.	Do....Supply of water insufficient for present needs during several months of the year.
Palmer Falls	...do	600	25	80	2,270	30	1,450 to 1,500 effective horse-power.	H. R. p. 17.	Do.
Cohoes	Mohawk river	1,400	10	104	9,450	104	6,556 effective horse-power in use in 1880.	H. R. p. 22.	Do.
Schaghticoke	Hoosac river	Several	Several	97½	2,210	49½	About 600 effective horse-power in use in 1882.	H. R. p. 34.	Do.
Big falls	Batten kill	265	7 to 12	106	2,170	106		H. R. p. 40.	Do ...Being developed in 1882.
Ticonderoga	Ticonderoga creek.	Several	Several	220 to 230	8,000+	175	Over 1,700 effective horse-power of wheels in use.	H. R. p. 63.	Power estimated for ordinary minimum, during 24 hours. Fall of 220 to 230 feet occurs in 2½ miles.
Carthage	Black river	Several	Several	55	6,250		1,120 effective horse-power of wheels in use.	L. O. p. 9.	Power estimated for low water of ordinarily dry years, night and day. Fall of 55 feet occurs in about 4,600.
Black River	...do			16	1,890	12	265± effective horse-power of wheels in use.	L. O. p. 11.	Power estimated for low water of ordinarily dry years, night and day.
Watertown	...do	Several	Several	122	14,550	79	4,675 rated effective horse-power of wheels in use.	L. O. p. 11.	Do....Large amount of power unemployed.
Remington's mill	...do	650	4½ to 6¾	50±	6,020	30	900 rated effective horse-power of wheels in use.	L. O. p. 16.	Do. do.
Brownville	...do	100	17 to 18	17±	2,070	17±	300± effective horse-power of wheels in use.	L. O. p. 16.	Do. do.
Oswego	Oswego river	530	12	20	1,990	12 to 20	2500± effective horse-power of wheels in use.	L. O. p. 24.	Do.
High dam	...do	363	13 to 14	15	1,960	15	200 effective	L. O. p. 27.	Do.
Fulton	...do	503	13½	16	2,050	16	3,130+ effective	L. O. p. 28.	Do.
Oswego Falls	...do	413	2 to 3	15	1,930	15			
Outlet of Keuka lake.				277	5,980	63½	420 effective	L. O. p. 35.	Power estimated as the average for a series of years.
Rochester	Genesee river	Several	Several	263	8,970		6,442 effective	L. O. p. 48.	Power estimated for low water of ordinarily dry years, night and day. Fall of 263 feet occurs within about 5 miles.
Lockport	Erie canal			57	2,590 to 3,238	57	1,400± effective	L. O. p. 61.	400 to 500 cubic feet per second assumed as available for power.

Large developed powers of the United States—Continued.

Locality.	Stream.	DAM. Length.	DAM. Average height.	Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.*			
New Jersey.									
Paterson	Passaic river	350	8	66	2,150 ±	66	About 2,350 gross or theoretical horse-power.	M. A. p. 130.	Power estimated for low season of ordinarily dry years, night and day.
Lambertville	Delaware river	900 ±	2 to 3	18 ±	5,450	18	540 ± effective	M. A. p. 95.	Power estimated for entire flow of the river in low season of ordinarily dry years, night and day. Power used from feeder of Delaware and Raritan canal. Fall of 18 feet occurs in 7 miles. Water is discharged partly to river and partly to lower level of canal.
Trenton	do	800 to 1,000	4 to 5	10 to 15	3,000 to 4,500	10 to 15	500 ± effective	M. A. p. 94.	Power estimated for low season of ordinarily dry years, night and day. Canal is 7 miles long. Power not economically developed.
Virginia.									
Richmond and Manchester.	James river	Several	Several	84	16,800	84	About 3,800 effective	M. A. p. 15.	Power estimated for low season of ordinarily dry years, night and day. Power not economically utilized.
Lynchburg	do			22	1,850	16	About 700 effective	M. A. p. 20.	Do.
At 15 dams on the	do			196	A total of 16,650	0	None	M. A. p. 23.	Power estimated for low season of ordinarily dry years, night and day.
Petersburg	Appomattox river.	Several	Several	110	2,940	78	About 1,275 effective	M. A. p. 24.	Do.
Georgia.									
Augusta	Savannah river	1,720	10.63	50 (at low water).	13,635	50	About 3,650 (effective?).	S. A. p. 127.	Do.
Columbus	Chattahoochee river.	Several	Several	120	34,080	50	2,100 ± effective	E. G. p. 22.	Do....Fall of 120 feet occurs within 5 miles of navigable waters.
Alabama.									
Tallassee Falls	Tallapoosa river	300 (wing-dam).	6 to 15	84	10,880	32	About 900 effective	E. G. p. 8.	Do....Probably not the entire fall of 84 feet is available.
Wisconsin.									
Appleton	Lower Fox river	700 450 417	16 10 10	36	10,200	36	Perhaps 3,800 effective.	N. W. p. 27.	Power estimated for ordinary low water.
Grand Kaukauna	do	613		50	14,182			N. W. p. 38.	Do.
Marinette	Menominee river	Several	Several	19	3,930	19	About 820 effective	N. W. p. 62.	Do.
Minnesota.									
Fergus Falls	Red river of the North.	Several	Several	40	6,225	83		N. W. p. 87.	Do.
Minneapolis (St. Anthony's Falls).	Mississippi river			70	25,000	50			Estimated power is probably not much above the minimum, during 24 hours.
Kansas.									
Lawrence	Kansas river	600	8	9	2,250	9	About 300 effective	M. R. p. 57.	Power estimated for low water of ordinarily dry years.

Large undeveloped powers of the United States.

[NOTE.—Abbreviations same as in foregoing table.]

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Sewell's falls, N. H.	Merrimack river	19	1.75 mile		N. E. p. 38.	Minimum power is several thousand horse-power continuously. See description.
Near Milton Three Ponds, N. H.	Salmon Falls river	200	About 3 miles.	Probably 2,000 to 2,500 at all times during working hours.	N. E. p. 67.	Flow controlled by mills below.
Salmon Falls, Me	Saco river	62	3,500 feet	2,400	N. E. p. 73.	Power estimated for low season of ordinarily dry years, night and day.
West Buxton, Me	do	62	About 2 miles.	2,300	N. E. p. 73.	Do.
Near Steep falls, Me	do	131	About 3 miles.	4,500	N. E. p. 73.	Do.
Rumford Falls, Me	Androscoggin river	162	About 1 mile.	13,252	N. E. p. 81.	Do.
Berlin falls, N. H	do	200	About 1 mile.	Very large	N. E. p. 81.	
Madison Bridge falls, Me.	Kennebec river	87	2½ miles	11,000–12,000	N. E. p. 87.	Power estimated for low season of ordinarily dry years, night and day. This site is utilized to a small extent.
Caratunk falls, Me	do	30	20 feet in one pitch.	3,000–3,500	N. E. p. 87.	Power estimated for low season of ordinarily dry years, night and day.
College rapids, Me	do	20	10 feet in 10 rods.	3,000	N. E. p. 87.	Do.
Piscataquis falls, Me	Penobscot river	22		3,000–3,500	N. E. p. 93.	Do.
Island Rapids, Me	do	15	1,650 feet	2,000–2,500	N. E. p. 93.	Do.
Near Norwich, Conn	Quinebaug river	50	About 6 miles.	1,760	L. I. p. 33.	Power estimated for low water of ordinarily dry years, night and day.
Sumner's falls, N. H. and Vt.	Connecticut river	15		2,560	L. I. p. 60.	Do.
Olcott or White River falls.	do	35		4,370	L. I. p. 60.	Do......Being developed in 1882.
Falls Village, Conn	Housatonic river	95		2,700	L. I. p. 146.	Do......No power used.
Above Troy, N. Y	Hudson river	18–30		3,070	H. R. p. 10.	Do. do.
Trenton Falls, N. Y	West Canada creek	200	About ½ mile.	1,820	H. R. p. 31.	Do. do.
Lyons Falls, N. Y	Black river	64½	250 feet	1,900	L. O. p. 8.	Do .....No power used, but it is proposed to improve this privilege.
Rawson's mill, N. Y	do	16±	600+ feet	1,820	L. O. p. 10.	Do......No power used, but this privilege was formerly developed.
Below Black River village.	do	45±	¾ mile	5,320	L. O. p. 11.	Do.
Two miles below Watertown, N. Y.	do	30±	3,000–4,000	3,610	L. O. p. 16.	Do.
Portage, N. Y	Genesee river	330	2–2½ miles	5,250	L. O. p. 47.	Do.
Little falls, Md. and Va.	Potomac river	10	At dam	2,600	M. A. p. 42.	Power estimated for low season of ordinarily dry years, night and day. Dam not tight.
Great falls, Md. and Va.	do	80–90	1½ mile	20,900+	M. A. p. 43.	Power estimated for low season of ordinarily dry years, night and day.
Weverton, Md	do	25	3 miles	5,100	M. A. p. 43	Do.
Harper's Ferry, W. Va.	do	22±	1½ mile	2,900	M. A. p. 44.	Do......Only about 125 horse-power utilized.
Do	Shenandoah river	84	8 miles	5,150	M. A. p. 48.	Do.
Conewago falls, Pa	Susquehanna river	10±	About 1 mile.	10,800	M. A. p. 63.	Do......Formerly partly utilized.
Port Deposit canal, Pa	do	80	9 miles	94,600	M. A. p. 64.	Do......Formerly a navigation canal.
Lambertville, N. J	Delaware river	14	About 4,100 feet.	4,400	M. A. p. 95.	Do......Power being partially developed, and a fall of 9 feet, with 165 effective horse-power intended to be used (1880).
Foul rift, near Belvidere, N. J.	do	23	About 2 miles.	4,000	M. A. p. 97.	Do......Entirely undeveloped.
Weldon, N. C	Roanoke river	84	9 miles	18,500	S. A. p. 29.	Do......Old canal in existence.
Smiley's falls, N. C	Cape Fear river	27	3½ miles	2,860	S. A. p. 57.	Do.
Buckhorn falls, N. C	do	20	½ mile	2,000	S. A. p. 58.	Do .....Old canal in existence.
Grassy Island shoal, N. C.	Yadkin river	36	Probably several miles.	8,680	S. A. p. 79.	Do......River very wide. No abrupt fall. Practically not all available.
Narrows of the Yadkin, N. C.	do	105	4 miles	14,910	S. A. p. 79.	Do......Practically unavailable.

Large undeveloped powers of the United States—Continued.

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Bean's shoal, N. C.	Yadkin river	39	4 miles	2,320	S. A. p. 81.	Power estimated for low season of ordinarily dry years, night and day. Old canal in existence.
Near Camden, S. C.	Catawba river	52	5 miles	8,850	S. A. p. 91.	Do......Old canal in existence. Power largely available.
Great falls of the	....do	173	8 miles	24,000	S. A. p. 92.	Do......Old canal in existence. A splendid power, largely available.
Landsford, S. C	....do	40	2 miles	5,270	S. A. p. 94.	Do......Old canal in existence.
Mountain Island shoal, N. C.	....do	40	3 miles	2,300	S. A. p. 95.	Do......A splendid power. Partially utilized by a cotton-mill.
Lookout shoal, N. C.	....do	54	3+ miles	2,100	S. A. p. 96.	Do.
Columbia, S. C	Congaree and Broad rivers	34	4 miles	6,700	S. A. p. 102.	Do......A splendid power. Old canal in existence.
Ninety-nine Islands shoal, S. C.	Broad river	17.26	2⅔ miles	3,250	S. A. p. 108.	Do.
Summers' shoal, S. C.	....do	11.61	0.94 mile	2,000	S. A. p. 108.	Do.
Lockhart's shoal, S. C.	....do	47.66	1.41 mile	4,500	S. A. p. 108.	Do......Not easy to utilize completely. Perhaps 3,000 horse-power easily available.
Ninety-nine Islands shoal, No. 2, S. C.	....do	50.62	3.20 miles	2,700	S. A. p. 108.	Do......Complete utilization impracticable.
Cherokee shoal, S. C	....do	50.95	2 miles	2,700	S. A. p. 108.	Do. do.
Mouth of river, S. C.	Saluda river	34	2½ miles	3,200	S. A. p. 117.	Do......Old canal in existence.
Blue Jacket shoal, S. C. and Ga.	Savannah river	10	600 feet	2,350	S. A. p. 129.	Do.
Long shoal, S. C. and Ga.	......do	35	5 miles	7,250	S. A. p. 130.	Do.
Trotter's shoal, Ga	......do	75	7 miles	9,165	S. A. p. 130.	Do.
McDaniell's shoal, Ga.	......do	30	5 miles	2,600	S. A. p. 130.	Do.
Portman's shoal, S. C	Seneca river	60	2 miles	1,950	S. A. p. 138.	Do.
Anthony's shoal, Ga	Broad river	*a*40	1½ mile	2,500±	S. A. p. 134.	Do......Fall and power can not be accurately stated.
Milledgeville, Ga	Oconee river	34	5 to 6 miles	2,860	S. A. p. 145.	Do......Not a very good site.
Macon, Ga.	Ocmulgee river	40±	10 miles	2,450	S. A. p. 153.	Do. do.
Wetumpka, Ala	Coosa river	80±	12 to 15 miles	19,360	E. G. p. 12.	Power estimated for low water of ordinarily dry years, night and day.
Total at 24 shoals above Wetumpka, on the Coosa river.	......do	277±		61,600	E. G. p. 13.	Do......No power utilized except for a single small grist-mill.
Etowah Mining and Manufacturing Company's privilege.	Etowah river	80	5 miles	3,360	E. G. p. 16.	Do.
Total at 28 shoals above Columbus, on the Chattahoochee river.	Chattahoochee river	528±		100,000	E. G. pp. 25, 26.	Do.
Louisville, Ky	Ohio river	26	2 miles	Very large	O. R. p. 7.	Canal around falls.
Cedars, Wis	Lower Fox river	9	(Dam)	2,553	N. W. p. 36.	Power estimated for ordinary low water. A dam is built across the river, but no power is utilized.
Little Chute, Wis	......do	34	6,500	9,644	N. W. p. 36.	Do......A dam 715 feet long and 11 feet high crosses the river, and a flour-mill uses about 100 horse-power.
Rapid Croche, Wis	......do	8	(Dam)	2,269	N. W. p. 41.	Do......A dam 525 feet long and 8 feet high crosses the river, and a small amount of power is used.
Little Kaukauna, Wis.	......do	7.5	(Dam)	2,127	N. W. p. 42.	Do......A dam 586 feet long and 7½ feet high crosses the river, and a small amount of power is used.
Big Quinnesec falls, Wis.	Menominee river	120	Short distance	14,905	N. W. p. 60.	Do......Would be very costly to develop full fall.
Little Quinnesec falls, Wis.	......do	80	Short distance	9,936	N. W. p. 61.	Do. do.
Sand Portage rapids, Wis.	......do	40	6 miles	5,078	N. W. p. 61.	Do.
Pemena falls, Wis	......do	70	2 miles	11,115	N. W. p. 61.	Do.
White rapids, Wis	......do	20	3 miles	3,275	N. W. p. 62.	Do.
Grand rapids, Wis	......do	25	3 miles	4,954	N. W. p. 62.	Do.
Twin Islands rapids, Wis.	......do	10	¾ mile	1,995	N. W. p. 62.	Do.
Schappee's rifts	......do	7	½ mile	2,024	N. W. p. 62.	Do.

a Probably not less.

Large undeveloped powers of the United States—Continued.

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Grand rapids, Minn....	Saint Louis river...........	75	5 miles........	9,645..........	N. W. p. 74.	Power estimated for ordinary low water.
Below Knife falls, Minn.	......do....................	154	4½ miles.......	20,451.........	N. W. p. 74.	Do.
Near mouth of....	......do....................	456	11 miles.......	63,293.........	N. W. p. 74.	Do......Of the total fall, 372 feet occur in the upper 4 miles. The total fall would not be available, but Mr. James B. Francis considered that three-fourths of it would be. This would give 47,469 horse-power.
Niagara river.........	From lake Erie to lake Ontario.	333	37 miles.......	6,294,000......	N. R. p. 11.	Power estimated for average flow. No power utilized except at falls.
Do..............	Niagara falls and rapids....	213	Less than a mile.	4,000,000......	N. R. p. 11.	Do......Total power of present wheels (1882) 5,200 effective horse-power.

The following table contains a compilation of information regarding water-power companies, prices for power, methods of regulating, etc. In it will be found, arranged geographically, all the localities where power is regularly leased, excepting some which may exist in the Mississippi basin, the report on which was, as has been mentioned, not accessible to the writer. It will be seen from this table that where power and not water is leased, the prices per theoretical horse-power range from $1 to $50 per annum. Probably the lowest price is that reported on the Lower Fox river in Wisconsin, while the highest rates (leaving out of consideration certain cases at some of the larger powers, where the use of surplus is in the nature of a violation of rule and is charged very heavily) are at Trenton, Paterson, and Passaic, New Jersey, Manchester, Virginia, and on the Great Miami river, in Ohio.

The cost of water-power in the United States.

[NOTE.—For explanation of abbreviations see table on page xxx.]

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Pawtucket, R. I...	Blackstone river..	....	Power owned by individuals.	Small amounts of power rented, generally with floor-space, and under special agreements.	Apertures proportioned to quantities owned.	N. E. p. 14.	Permanent power completely utilized.
Central Falls, R. I.	....do..........	....	...do..........	No power rented.............	......do..............	N. E. p. 14.	Do.
Woonsocket, R. I..	....do..........	....	...do..........	......do...................	Weirs whose lengths are proportioned to quantities owned.	N. E. p. 14.	Do.
Lawrence, Mass...	Merrimack river..	Minimum is 11,000 gross horse-power during working hours.	Essex Company..	$14 08 per gross horse-power per annum for constant power 16 hours per day; surplus power at from 4.7 cents to 9.4 cents per gross horse-power per day, according to amount used.	Weir and flume measurements, etc., carried on with the greatest care.	N. E. p. 25.	Permanent power nearly all utilized.
Lowell, Mass......	....do..........	Minimum is about 11,845 gross horse-power during working hours.	Proprietors of Locks and Canals on Merrimack river.	Original cash payment and annual rent of $3 53 per gross horse-power for constant power 15 hours per day; surplus power at from 1.2 to 23.5 cents per gross horse-power per day, according to amount used and stage of the river.	......do..............	N. E. p. 30.	All the permanently available power is utilized.
Manchester, N. H..	....do..........	Minimum is about 12,000 gross horse-power during working hours.	Amoskeag Manufacturing Company.	Original cash payment and annual rent of $3 47 per gross horse-power for constant power 16 hours per day; surplus power at 5.8 cents per gross horse-power per day.	Observations on height of speed-gate and of water in pen-stock and pit.	N. E. p. 35.	Do.
Biddeford and Saco, Me.	Saco river.......	1,700 gross horse-power in low season of ordinarily dry years, without storage.	Saco Water Power Company.	Permanent power owned. Rate for surplus power 3.52 cents per gross horse-power per day.	Daily observations of height of speed-gate and of water in pen-stock and pit.	N. E. p. 72.	Do.
Lewiston, Me......	Androscoggin river.	Minimum is nearly 12,000 gross horse-power during working hours.	Union Water Power Company.	$1 87 to $9 37 per gross horse-power per annum.	Measurements lately made, once for all, to determine quantity used by each mill.	N. E. p. 80.	Nearly all the permanently available power is utilized.
Windsor Locks, Conn.	Connecticut river.	17,000 theoretical horse-power in low water of ordinarily dry years, night and day for entire river. Practically limited by existing works to a less amount.	Connecticut River Company.	Perpetual lease of water and land. Nominal water-rental is $2 50 per square inch of orifice under a head of 30 inches, equivalent to $13 50 per annum per gross or theoretical horse-power with a fall of 30 feet, and $20 30 with a fall of 20 feet.	....	L. I. p. 48.	

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Holyoke, Mass	Connecticut river.	24,000 theoretical horse-power in low water of ordinarily dry years, night and day.	Holyoke Water Power Company.	Rate for permanent power can not be stated; surplus power at 2.9 cents per theoretical horse-power for 12 hours.	Tests of wheels previous to setting, and daily observation of heights of gates, and of water in pen-stock and pit.	L. I. p. 51.	Greater part of utilized power employed for paper-mills. Considerable power still available.
Turner's Falls, Mass.	....do	17,600 theoretical horse-power in low water of ordinarily dry years, night and day.	Turner's Falls Company.	Usual rate has been $7 50 per annum per horse-power (not further specified), but there is no established rate for the future.	Weir measurements in the tail-races made as often as desirable.	L. I. p. 56.	Do.
Bellows Falls, Vt	....do	12,000 theoretical horse-power in low water of ordinarily dry years, night and day.	Bellows Falls Canal Company.	Nominal rate $7 50 per annum per horse-power (not further specified).	No accurate measurements made; quantities rated for wheels in use are accepted in practice.	L. I. p. 58.	Power nearly all employed for paper-mills.
Unionville, Conn	Farmington river.	860 theoretical horse-power in low water of ordinarily dry years, night and day.	Union Water Power Company.	Perpetual lease at $175 per mill-power per annum, a mill-power being 7½ cubic feet per second under a head of 18 feet, or 15.34 theoretical horse-power; that is, the price is $11 35 per theoretical horse-power per annum.	Quantity used determined by wheel-ratings without measurement.	L. I. p. 76.	All the permanent power is already in use.
Greeneville, Conn.	Shetucket river	Total rated power of wheels in use, 1,600 or 1,700 horse-power.	Norwich Water Power Company.	Water-rights sold with a reserved annual rental of $130 per 1,000 spindle-power.	Quantity determined by area of opening at head-gates.	L. I. p. 20.	
Occum, Conn	....do	290 theoretical horse-power in low water of ordinarily dry years, night and day.	Occum Company	$20 per annum per horse-power (not further specified).	....	L. I. p. 22.	About 180 (?) horse-power in use.
Barrett's Junction, Mass.	Swift river	200 theoretical horse-power in low water of ordinarily dry years, night and day.	Barrett's Junction Water Power Company.	$9 per annum per horse-power (not further specified).	....	L. I. p. 102.	About 125 effective horse-power utilized.
Birmingham, Conn.	Housatonic river	1,375 theoretical horse-power in low water of ordinarily dry years, night and day.	Oosatonic Water Company.	Power leased for ninety-nine years, per square foot. *Permanent water*, $20 per annum per theoretical horse-power; *first surplus*, $12 per annum per theoretical horse-power; *second surplus*, $8 per annum per theoretical horse-power. Company does not guarantee power in any case.	Float or weir measurements made when considered necessary, but not regularly.	L. I. p. 141.	Power to be used 12 hours per day. Permanent power still available.
Do	Naugatuck river	Total effective (rated) power of wheels in use, 590.	Birmingham Water Power Company.	....	Flume and orifice in tail-race.	L. I. p. 148.	Permanent power all leased.
Ansonia, Conn	....do	Total effective (rated) power of wheels in use, 1,600 horse-power.	Ansonia Land and Water Power Company.	Water leased by the square foot, under a head of 30 inches estimated to produce 30 theoretical horse-power. *Permanent water*, $600 per annum per square foot; *surplus water*, $250 to $500 per annum per square foot.	Accurate measurements are not attempted.	L. I. p. 148.	Ordinary power of privilege fully in use.
Cohoes, N. Y	Mohawk river	9,450 theoretical horse-power in low water of ordinarily dry years, night and day.	The Cohoes Company.	Perpetual lease of land and power with reserved rent amounting to $14 67 per annum per theoretical horse-power.	Weir and flume measurements, made whenever there is a change in the running of the wheels, or oftener if necessary.	H. R. p. 24.	The company still has permanent power to lease.
Oswego, N. Y	Oswego river	1,170 theoretical horse-power in low water of ordinary years, night and day.	Oswego Canal Company.	999-year lease of water. Water leased by the "run" equal to 11⅔ cubic feet per second under 20 feet fall. Price of *first-class runs* equals $13 11 per annum per theoretical horse-power; of *second-class runs*, $9 36 to $11 24; of *surplus runs*, $6 55 to $8 74.	....	L. O. p. 25.	
Do	....do	820 theoretical horse-power in low water of ordinary years, night and day.	Two individuals	Perpetual lease of water by the "run", or 33⅓ cubic feet per second under a head of 10 feet. Cost of *first-class runs*, from $6 60 to $7 92, and of *second- and third-class runs*, from $3 30 to $3 96 per annum per theoretical horse-power.	....	L. O. p. 25.	
Rochester, N. Y	Genesee river	8,970 theoretical horse-power in low water of ordinarily dry years, night and day.	Owned principally by the manufacturers themselves.	At one privilege power is rented at $25 per annum per effective horse-power.	Water drawn from canals over weirs, whose lengths are proportioned to amount of power owned. Weirs adjusted by commissioners appointed by the court.	L. O. p. 48.	With the present development, all the mills can be run at full capacity during only nine or ten months in the year.

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Lockport, N. Y	Erie Canal	2,590 to 3,238 theoretical horse-power.	Lockport Hydraulic Company.	Perpetual lease or absolute purchase. Price from $8 33 to $11 11 per annum per theoretical horse-power.	Amount judged from wheel-ratings, with occasional measurements in the tail-races.	L. O. p. 61.	Water-power reliable for the greater part of the year, but not always.
Niagara Falls, N. Y	Niagara river	About 4,000,000 theoretical horse-power in ordinary stage, night and day.	Niagara Falls Hydraulic Power and Manufacturing Company.	When company maintains water-wheels and main shafting, the price is $10 per horse-power (not further specified) per annum. When manufacturers supply their own wheels, price is $7 per horse-power per annum up to 1,000 horse-power, and less for larger powers.	Not stated	N. R. p. 14.	Enormous power still available.
Passaic, N. J	Passaic river	About 800 theoretical horse-power in low season of ordinarily dry years, night and day.	Dundee Water Power and Land Company.	About $33 33 per annum per gross or theoretical horse-power for 12 hours a day.	No regular measurements made. Prices based on a measurement made, once for all, several years ago.	M. A. p. 132.	
Paterson, N. J	....do	About 2,150 theoretical horse-power in low season of ordinarily dry years, night and day.	Society for Establishing Useful Manufactures.	$750 per annum per square foot of orifice under a head of 2.75 feet to center, equivalent to about $36 per annum per theoretical or gross horse-power.	No regular measurements made. Orifices in flumes or apertures in turbines used as basis of calculations.	M. A. p. 130.	All the permanent power already utilized.
Raritan, N. J	Raritan river	216 theoretical horse-power in low season of ordinarily dry years, night and day.	Raritan Water Power Company.	Nominal price, $300 to $400 per annum per square foot of orifice under a head of 30 inches to center of orifice.	None, except, perhaps, by orifices.	M. A. p. 126.	Power not economically developed.
Trenton, N. J	Delaware river	3,000 to 4,500 theoretical horse-power in low season of ordinarily dry years, night and day.	Trenton Water Power Company.	$3 and $4 per square inch under a head of 3 feet; equivalent to about $37 50 and $50 per annum per theoretical horse-power.	No measurements made regularly. A measurement was made several years ago, once for all, and prices fixed accordingly.	M. A. p. 94.	About 500 gross horse-power utilized.
Fredericksburg, Va	Rappahannock river.	1,360 theoretical horse-power in low season of ordinarily dry years, night and day.	Fredericksburg Water Power Company.	From $5 to $15 per horse-power (not further specified).	No measurements made.	M. A. p. 36.	
Manchester, Va	James river	Can not be stated	City of Manchester.	50-year leases at $4 per annum per square inch of orifice under a head of 3 feet, corresponding theoretically to between $29 60 and $42 10 per annum per theoretical horse-power, according as the fall is 20 or 14 feet.	No precautions taken to regulate exactly the amount of water used.	M. A. p. 15.	Generally sufficient water for all mills at present running.
Augusta, Ga	Savannah river	13,635 theoretical horse-power in low season of ordinarily dry years, night and day.	City of Augusta	$5 50 per horse-power (not further specified).	Optional with city engineer.	S. A. p. 127.	Price *probably* refers to gross or theoretical horse-power.
Hamilton, Ohio	Great Miami river		Hamilton and Rossville Hydraulic Company.	Water leased in "mill-stone powers"; price is equivalent to from $19 09 to $44 05 per annum per theoretical or gross horse-power.	Water delivered over fixed iron weirs.	O. R. p. 48.	Permanent power completely utilized.
West Hamilton, Ohio.	....do		West Hamilton Hydraulic Company.	$200 per annum per "run", which equals 375 cubic feet per minute.		O. R. p. 49.	Do.
Middletown, Ohio	....do		Middletown Hydraulic Company.	$28 94 per annum per theoretical horse-power. Company reserves right to shut off water 30 days in the year.	Fixed weirs	O. R. p. 49.	Do.
Franklin, Ohio	....do	600 theoretical horse-power in low water of ordinarily dry years, night and day.	Franklin Hydraulic Company.	$29 37 per annum per theoretical horse-power.	None, on account of abundance of water.	O. R. p. 50.	Permanent power not all utilized. Effective power of wheels in use, 280 horse-power.
Dayton View, Ohio	....do	270 theoretical horse-power in low water of ordinarily dry years, night and day.	Dayton View Hydraulic Company.	$36 71 per annum per theoretical horse-power, in 99-year leases.		O. R. p. 51.	150+ effective horse-power of wheels in use.
Dayton, Ohio	Mad river		Dayton Hydraulic Company.	$30 21 per annum per theoretical horse-power.	Adjustable orifices	O. R. p. 52.	
Do	Miami and Erie canal.		Cooper Hydraulic Company.	The greater part at $24 75 and $27 93 per annum per theoretical horse-power.	Fixed apertures	O. R. p. 63.	

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Appleton, Wis	Lower Fox river	10,200 theoretical horse-power at ordinary low water.		Power leased with necessary land. A 500 to 1,000 horse-power site at $1 to $2 per annum per horse-power; a 100 to 300 horse-power site at $3 to $4 per annum per horse-power; a 50 horse-power site of one-half acre at $2 to $3 per annum per horse-power.		N. W. p. 19. p. 27,	
Kaukauna, Wis	do	14,182 theoretical horse-power at ordinary low water.	Kaukauna Water Power Company.	A 100 to 300 horse-power site at from $2 to $5 per annum per horse-power.		N. W. p. 20, p. 38.	
Lawrence, Kans	Kansas river	2,250 theoretical horse-power at low water of ordinarily dry years.	Mr. J. D. Bowersock.	$20 per horse-power	Power not measured, but estimated approximately.	M. R. p. 57.	

The following table contains condensed information regarding water-power used from navigation canals, with rates for power, etc.:

Water-power used from navigation canals.

[NOTE.—For explanation of abbreviations, see table on page xxx.]

Canal or company.	Conditions of lease.	Rates for power.	Methods of regulating.	Total amount of power used; effective horse-power.	Reference in these volumes.	Remarks.
New York State canals.	Surplus water only; policy of the state is not to dispose of any more power; water entirely drawn off at times.	Leased to highest bidders		2,391	L. O. p. 61.	Excluding power at feeder-dams.
Delaware and Raritan canal.	Surplus water only; no guarantee, and water entirely drawn off at times.	Nominal price, $3 per square inch under a head of 3 feet, but special agreements often made.	None		M. A. p. 96.	Principal use of power is on the feeder-canal, at Lambertville, New Jersey, where about 540 horse-power is used.
Lehigh Canal and Navigation Company.	Surplus water only; water drawn off at times.	From $1 to $4 per square inch of aperture under a head of 3 feet to center of orifice, according to the fall and other circumstances.	Standard orifice put in	About 800	M. A. p. 107.	Company still has some power to dispose of.
Schuylkill Navigation Company.	Surplus water only; but quantity so regulated that a steady power can be maintained.	For mills running 10 hours per day, $6 per square inch per annum; for mills running 24 hours, $7 50 per square inch per annum, under a head of 3 feet to center of aperture.	Flume measurements where turbines are used, and standard apertures for other wheels.	About 1,750	M. A. p. 104.	
Pennsylvania canal	Surplus water only; no guarantee of water or power, and water drawn off at times.	Perhaps $2 to $5 per horse-power per annum, but no regular rates.	None	About 400	M. A. p. 63.	Considerable power is available at the locks, about 5,700 theoretical horse-power in all over the entire canal.
Chesapeake and Ohio canal.	Surplus water only; no head or quantity guaranteed; water drawn off at times.	$2 50 per square inch per annum, in 20-year leases.	Water leased by square inch of opening, and a standard orifice is specified.	Perhaps 1,500	M. A. p. 41.	Principal use of power is at Georgetown, D. C., where about 1,200 horse-power is utilized.
James River and Kanawha canal.	Surplus water only	According to location, $3, $1 10, and 70 cents per cubic foot per second for each foot fall, equal to respectively $26 41, $9 68, and $6 16 per gross or theoretical horse-power per annum.	Water delivered through an orifice.		M. A. p. 17.	This canal is now abandoned.
State of Ohio	At dams on Muskingum river; surplus power leased under 30-year leases, and at expiration of lease power sold by auction; state reserves right to shut off water one month in the year.	No uniformity in rates	Leases specify that water shall be taken over weirs, but practically they are not used.	1,100 to 1,200 rated power of wheels.	O. R. p. 36.	
Ohio State canals	Surplus water flowing around a certain lock; or water sufficient for a certain number of runs of stones; or a certain number of cubic feet per minute. Right reserved to shut off water for 30 days per year.	do	Practically none	6,618	O. R. p. 59.	Many powers still unutilized.

Finally, the following table shows the power utilized, by drainage basins, only the larger streams being specified. From this it is seen that the basin of the Blackstone is the one in which there is the greatest amount of water-power utilized per square mile, while in the basins of the Missouri, Arkansas, and Red rivers the utilized water-power is practically *nil* in proportion to the area drained:

Stream.	Drainage area.	Utilized net or effective horse-power.	Utilized power per square mile.	Approximate rank.
	Sq. miles.		*H. P.*	
Blackstone river	458	19, 994	43. 655	1
Taunton river	337	4, 097	12. 157	4
Charles river	281	3, 362	11. 964	5
Merrimack river	4, 916	88, 818	18. 067	3
Saco river	1, 753	8, 129	4. 637	15
Presumpscot river	726	5, 430	7. 479	9
Androscoggin river	3, 698	15, 741	4. 257	18
Kennebec river	6, 404	11, 277	1. 761	20
Penobscot river	8, 785	9, 200	1. 047	28
Saint Croix river in Maine	1, 674	772+	0. 461	45
Saint John river in Maine	7, 998	862±	0. 108	53
Connecticut river	10, 924	118, 026	10. 804	7
Thames river	1, 450	30, 523	21. 050	2
Housatonic river	1, 933	21, 159	10. 946	6
Hudson river	13, 366	82, 910	6. 203	13
Passaic river	962	8, 159	8. 481	8
Raritan river	1, 098	4, 977	4. 533	16
Delaware river	10, 100	43, 355	4. 293	17
Schuylkill river	1, 912	12, 096	6. 326	11
Susquehanna river	26, 233	70, 283	2. 679	19
Potomac river	14, 500	18, 790+	1. 296	25
Rappahannock river	2, 700	2, 371	0. 878	33
James river	9, 700	13, 323	1. 374	24
Roanoke river	9, 200	8, 426	0. 916	31
Tar river	3, 000	2, 571	0. 857	34
Neuse river	5, 299	3, 250	0. 613	39
Cape Fear river	8, 400	7, 121	0. 848	35
Great Pee Dee river	17, 000	8, 121	0. 478	43
Wateree river	5, 225	5, 158	0. 987	29
Congaree river	7, 965	7, 654	0. 961	30
Savannah river	10,000–11,000	11, 778	1. 122	26
Ocmulgee river	6, 000	3, 100	0. 517	41
Oconee river	5, 400	3, 486	0. 646	38
Alabama river	23, 700	10, 169	0. 429	46
Tallapoosa river	4, 935	2, 445	0. 495	42
Coosa river	10, 610	6, 257	0. 590	40
Appalachicola river	19, 580	12, 989	0. 663	37
Chattahoochee river	9, 100	9, 785	1. 075	27
Flint river	8, 420	3, 204	0. 381	48
Black river, New York	1, 857	13, 029	7. 016	10
Oswego river	5, 013	31, 488	6. 281	12
Genesee river	2, 496	13, 898	5. 568	14
Allegheny river	11, 107	19, 340+	1. 741	22
Monongahela river	7, 625	5, 795	0. 760	36
Beaver river	3, 030	4, 602	1. 519	23
Little Kanawha river	2, 290	509	0. 222	50
Muskingum river	7, 740	7, 066	0. 913	32
Scioto river	6, 400	3, 008	0. 470	44
Great Miami river	5, 400	9, 489+	1. 757	21
Dakota river	22, 000	228	0. 010	63
Big Sioux river	7, 880	673	0. 085	56
Tributaries of the Missouri river in southeast Dakota.	32, 110	1, 034	0. 032	62
Tributaries of the Missouri river in western Iowa.	10, 000	2, 265	0. 227	49
Tributaries of the Missouri river in northern Missouri.	17, 000	2, 958	0. 174	51
Platte river and tributaries	90, 000	4, 157	0. 046	59
Kansas river and tributaries	59, 750	6, 561	0. 109	52
Osage river and tributaries	15, 262	1, 347	0. 088	55
Gasconade river and tributaries	3, 700	386	0. 104	54
Missouri River basin	527, 000	21, 012	0. 039	60
Eastern Iowa slope	35, 995	15, 410	0. 428	47
Eastern Missouri slope	18, 800	1, 466	0. 078	57
Arkansas river	188, 143	7, 076	0. 038	61
White river, Arkansas	27, 925	2, 146	0. 077	58
Red river	92, 700	778	0. 008	64

GEO. F. SWAIN,
Special Agent, Tenth Census.

NEW YORK, N. Y., *December*, 1885.

I have examined the above summary, prepared by Mr. Swain, in connection with the various reports to which it relates, and give it my unqualified indorsement.

It was originally arranged that this summary should be prepared by Mr. Swain and myself jointly, but the pressure of other duties has prevented me from taking any part in it except to examine and approve it. I regard it as a most thorough, complete, and scholarly abstract and presentation of the results of the reports.

W. P. TROWBRIDGE.

REPORT ON THE WATER-POWER

OF THE STREAMS OF

EASTERN NEW ENGLAND,

GEORGE F. SWAIN, S. B.,

ASSISTANT PROFESSOR OF CIVIL ENGINEERING IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON, MASS.,

SPECIAL AGENT.

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BOSTON, MASS., *April* 30, 1883.

Professor W. P. TROWBRIDGE,

Chief Special Agent, Tenth Census, Columbia College, New York, N. Y.

SIR: I have the honor to submit herewith a report upon the water-power of eastern New England, giving the results of investigations carried on under your direction during the summer of 1882. This completes the series of reports intrusted to my care, and, as in those previously completed, the aim has been to give a reliable account of the great powers in the region considered, as well as a general discussion of its water-power in general. The suspension of field operations in the summer of 1881, and the limited time at my disposal after their renewal in 1882, rendered impossible a personal examination of the state of Maine, and a hurried visit to a few of its great powers was all that could be attempted in that state. Fortunately, however, the water-power of Maine has been ably and exhaustively treated in a report by Mr. Walter Wells, made in 1869, by the use of which, as well as by extensive correspondence, the data given have, it is hoped, been made reasonably accurate.

My thanks are due to many gentlemen who have assisted me in my work, and who are referred to in the body of the report.

Very respectfully, your obedient servant,

GEORGE F. SWAIN.

WATER-POWER OF EASTERN NEW ENGLAND.

I.—INTRODUCTION.

The territory to be covered by the present report comprises that part of New England draining into the Atlantic ocean east of the Thames river, Connecticut. Before proceeding to discuss the various streams draining this district, its general characteristics should first be given; and the following brief *résumé* of the principles or circumstances upon which the value of powers depend will aid in forming a just estimate of the water-power of New England.

GENERAL CONSIDERATIONS.

A water-power is produced when a certain quantity of water falls through a certain distance. The greater the fall, and the greater the quantity of water, the greater the power; but if the quantity of water varies from day to day, that which flows in the period of minimum flow is all that is permanently available, while at other times there will be large amounts in excess. A good power, then, supposes a good fall, a considerable quantity of water, and a small variation in that quantity. Let us take up these three points in succession. What conditions, then, are favorable to the existence of large falls on rivers? In general, the streams must have a considerable declivity. If a stream has an average fall which is large, we may, in general, conclude that it possesses considerable power. Theoretically the power which it possesses depends upon the average quantity of water which it discharges from source to mouth, and the total fall between those two points. But there may be great differences in regard to the availability of this power. If the stream possesses natural falls of considerable magnitude in short distances, then by diverting the waters, and carrying them in canals past the falls, powers may be rendered available; but if there are no concentrated falls, and only a uniform declivity, then, in order to produce a power, a dam must be erected which shall raise the level of the water for some distance and produce a sudden fall. The erection of a dam, however, is often accompanied by the overflowing of considerable areas of valuable land above, depending on the character of the banks of the stream; and there is often danger of the breaking away of the dam in times of freshet, if it is not founded on solid material. In addition to a great declivity, then, it is necessary that a stream should possess concentrated falls and rapids, and it is, moreover, desirable that its banks shall be high and firm, affording good foundations for building, and not comprising much low land which would be liable to overflow were the water-level raised a few feet. The formation of a large pond by the erection of a dam, however, if not attended with too much expense, is an extremely favorable circumstance, as, if large enough, it allows of the storage of the water during the night, and the utilization during twelve hours, or less, of the entire flow in twenty-four. Falls and rapids generally occur when a stream crosses ledges of rock. It is therefore important that a stream shall have cut down its bed to the underlying rock, and that its drainage basin shall be underlaid with rocks at a moderate depth. If a fall or rapid is to be permanent, the rocks which cause it must be hard and impervious, otherwise they will be gradually worn away and the fall obliterated. If a stream flows at right angles across the upturned edges of a series of rock strata, the falls are apt to be greater and more numerous than if the stream runs parallel to the rock strata; it is hence a favorable circumstance if the strike of the rock strata is at right angles to the general course of the streams. A swampy country is, of course, not favorable to the existence of falls, neither is a country deeply overlaid with drift. In such cases, and generally in cases where the declivity is gradual, the bed is apt to be of movable material and the construction of a dam attended with some uncertainty.

Upon what circumstances, again, does a large average flow depend? By average flow we mean the average quantity of water discharged during a year; and, inasmuch as all the water flowing in a stream is derived from the rainfall, it is at once evident that a first requisite is a large annual rainfall. Further, the rainfall must be so

distributed through the year that there shall be the least loss by evaporation; hence in winter, when the evaporation is least, the rainfall must be largest. Again, the smaller the evaporation the less the loss from that source; hence a low annual temperature, and especially a low summer temperature, is a favorable circumstance. A pervious soil, which shall absorb the water rapidly, removing it from the action of the sun's rays, is also favorable.

But the most important requisite in regard to flow is that it be uniform, for it is only the lowest flow that is permanently available. A large number of circumstances affect the distribution of the flow through the year. First, there is the question of storage. If the surplus waters which flow in wet seasons and in freshets can be stored up and held until dry seasons, then a tolerably uniform flow may be secured; but the amount of storage capacity available must be greater, as the natural variability of the flow is greater. The presence of lakes and of facilities for artificial storage is therefore a most favorable circumstance, especially if they are deep, for then they expose less surface to the influence of evaporation. But it is evident that for uniform flow the rainfall should be greatest in summer, when the loss by evaporation is greatest; and this distribution is unfavorable to a large average flow. If large storage capacity is available, a small summer rainfall is not detrimental; but in a region without lakes it is, no doubt, a great factor contributing to a variable flow. A deep and pervious soil is a favorable factor, as it serves as a sort of reservoir, absorbing the rain which falls, and giving it out gradually by springs. This element, however, is less important in a country where there are numerous lakes, and where the rainfall is favorably distributed for uniform flow; in other cases it is very important. A low summer temperature is favorable here, as well as in regard to average flow, diminishing the evaporation when it is greatest. Extensive forests have a very great effect in regulating flow, by diminishing the amount of water flowing directly from the surface and increasing the amount percolating, to be given out elsewhere by springs. As regards topography, the most favorable condition is one which neither allows of a rapid discharge of the water falling on the surface, occasioning sudden freshets, nor of a very slow discharge and long exposure to the influence of evaporation. A mountainous country generally favors rapid discharge of storm waters, especially if the slopes are steep, rocky, and not wooded; hence streams in mountain regions are seldom of any value for manufacturing. A very flat country, on the other hand, allows of a very large evaporation, and consequently of a small average flow of the streams, and such a topography is not favorable to the existence of abrupt falls. A country which is moderately hilly is in general the most favorable. The shape of the drainage basins of the streams has also an effect. We shall meet with numerous examples of the fact that where a stream cuts across a series of parallel ranges, so that its tributaries have long and narrow basins, draining the parallel valleys between the ridges, a variable flow is to be expected, especially if the slopes are steep and the ridges high, for the rain is very apt to fall in such cases on one or a few slopes, or over several adjacent drainage basins, suddenly swelling enormously a few tributaries and the main stream. If mountains are arranged in well-defined ridges one slope is apt to have a greater rainfall than another, while if they are irregularly arranged in clusters a more uniform distribution of the rainfall is the result, and hence a more uniform flow of the streams. Again, the greater the area of the drainage basins the more uniform will be the flow, because the effect of sudden rains is comparatively smaller. The state of cultivation has also an effect on the average flow as well as on its distribution, for from cultivated ground the rain will not be shed so rapidly as from uncultivated ground; hence the flow will be more uniform in the former case, but the average flow less.

Finally, it is important to notice that one other important element of a good water-power is accessibility either by sea or by land; and, consequently, that a topography which is favorable to the location of railways along the rivers, and not along the divides, is favorable as regards water-power. In this respect high banks, with few extensive bottom-lands subject to overflow, are essential.

We proceed now to describe the general characteristics of eastern New England in the light of what has preceded, and to study the general effects of these circumstances on its water-power.

1.—Area and form.

The region to be considered embraces a land area of about 41,000 square miles, distributed as follows among the different states:

	Square miles.
Maine	29,895
New Hampshire	6,276
Massachusetts	3,750
Rhode Island	1,035
Connecticut	164
Total land area	41,120

This area forms a strip extending along the Atlantic between the parallels of about $41\frac{1}{3}°$ and $47\frac{1}{2}°$ north latitude. It is narrowest at the south, measuring 75 or 80 miles in width, and widest at the north, where it is about 200 miles wide. Its greatest length is about 480 miles. The coast-line runs in a southwesterly direction at the north, then south, and finally west in the southerly part of the region.

2.—Geographical and continental position.

The district considered, being situated at the northeasterly corner of the United States, bounded on the east and south by the ocean, has an exposure which is maritime to an unusual degree. Not only are the winds maritime from the south, southwest, east, and northeast, but also those from the north and northwest are far from bearing the character of land winds, having passed over considerable areas of water in the more northerly part of the continent. We may say, therefore, that only the winds from southwest to northwest are distinctly land winds, arid, and unfavorable to the amount and constancy of water-power. The winds from about two-thirds of the compass are more or less maritime. The ocean exposure of the district on the south, and the greater proportion of oceanic winds, are especially favorable, contrasted with the conditions found in the middle states. The prevalent winds through both regions are from the west or southwest, but it is the winds from the south and southwest which bring the moisture. In New England these winds come directly from the ocean, and are charged with vapor; in the middle states they have been in great part robbed of their moisture in their passage over the southern states, so that this region obtains most of its rain from the easterly and southeasterly winds, which are neither so frequent nor so warm, and hence not such good carriers of moisture as those from the south and southwest. The rainfall over New England is therefore larger in amount and more uniform in its distribution through the year than that in the middle states, and by far more uniform than that in the southern states. The continental and geographical position of the district to be considered is therefore more favorable to the existence of fine water-powers than that of any other region on the Atlantic slope, and probably more than that of any other region in America.

3.—Topography.

Topographically, the region lies entirely on the eastern slope of the Appalachian mountain system, and in a part of that system where the development of parallel ranges is but slightly pronounced. Unlike the streams of the middle states, which take their rise on the western side of the mountains, on an elevated plateau, and flow across the mountains, their tributaries draining a series of parallel and narrow valleys, the streams we are to consider, like those of the southern Atlantic states, rise on the eastern flank of the mountain system and are confined entirely to the Atlantic plain, flowing in a general southeasterly direction, excepting the streams in the north of Maine, which flow first in a northeasterly direction, bending afterward and flowing southeast. The western water-shed, or divide, of the district, starting from Long Island sound, at the ocean-level, pursues a northerly course through Connecticut, Massachusetts, and New Hampshire for about 200 miles, when it bends slightly toward the east and continues for about 280 miles, corresponding for a short distance with the boundary between Maine and Canada, and finally passing into the province of Quebec. In its course through Connecticut its elevation above the sea is small, but it gradually rises in Massachusetts and New Hampshire, till in the latter state it reaches its greatest elevation on the White mountains, beyond which it gradually falls. From this main divide a secondary one branches off toward the east, extending almost entirely across the state of Maine, from the sources of the Penobscot, and dividing the surface of that state into two slopes, a southern and a northern. In all the region except the northern slope of Maine the general course of the streams is south or southeast, this region forming the true Atlantic slope. In the northern slope of Maine, which comprises an area of about 7,400 square miles, their course is east-northeast.

Of the three parts into which we may divide the Atlantic plain in the case of the middle and southern states, viz, the eastern, the middle, and the western or mountainous, the eastern well-nigh disappears in New England, being scarcely found except in eastern Massachusetts and in Rhode Island. The *fall-line*, which bounds that region on the west, and which marks the division between the area of metamorphic rocks and that of the flat and low Tertiary and post-Tertiary deposits, runs in New England close to the coast. Granite is found within sight and sound of the sea, and the tidal and navigable portions of the rivers are of short length. The head of tide is always the head of navigation, and at this point there is generally a fall, often a large and important one. The mountain division, unlike that of the middle states, is likewise of small importance, partly because it is not of large extent, and partly because the streams within it are generally small. It is confined to the middle and northern parts of New Hampshire and a triangular portion of Maine, comprising the central portion of the state, with its greatest breadth on the west, and forming the divide between the northern and the southern slopes. In this region there are no parallel valleys, no considerable streams running for long distances without any large affluents, and consequently less severe and sudden freshets than on the streams of the middle and southern states, though this is due in great measure to other causes, which will be referred to in the proper places. The arrangement of the mountains in clusters and irregular ranges, instead of in long and parallel ridges, is favorable to a uniform distribution of the rainfall and to its gradual discharge. The mountain region is here neither so high nor so extensive as in the southern states, but is higher, though much less extensive, than in the middle states. Its effect upon the water-power of the streams is not to injure it particularly, which is more than can be said in regard to many states farther south. The favorable effect of the small extent of the eastern or tidal division in bringing the water-powers within easy reach of the sea-board, and thus facilitating transportation, need not be dwelt upon.

The greater part of the region is occupied by the true Atlantic plain, or middle division, comprising the southern slope, and extending from the coast to the foot of the mountains, averaging about 50 miles in breadth. It comprises nearly all of Rhode Island, Connecticut, and Massachusetts, the southern part of New Hampshire, and the greater part of Maine. Its elevation at the foot of the mountains varies from about 300 to 500 feet, being greatest near the elevated mountain region of New Hampshire; and its slope toward the sea is, on the whole, uniform, extending across the whole breadth of the region, and quite to tide-water. It contains almost all the water-powers of importance, which are equally abundant in all parts, existing even at the very mouths of the rivers, where they are largest. When this peculiarity is contrasted with the condition of things in the southern Atlantic states, where the streams are navigable for over 100 miles from their mouths, the advantage possessed by the New England streams will be manifest, in regard to both the magnitude of the powers and their accessibility. This southern slope, which possesses all the great water-powers of the region, is singularly well adapted for their utilization. The streams have a rapid fall, those having their sources near the elevated region in New Hampshire being the most favored in this respect. Their beds are generally of rock at the places where falls occur, with drift deposits in the intermediate distances, and their banks are uniformly high and firm. Unlike the southern streams, there are no swamps or meadow-lands of importance along their courses, so that even in high freshets very little land is overflowed. Dam succeeding dam, almost the whole fall of many of these streams may be economically utilized. The country is moderately hilly, a fact already referred to as favorable. The river valleys and the streams also are narrow at the places where falls occur, so that often only short dams are necessary. The streams are not navigable on account of their many rapids, and consequently are principally used for power.

The slope of northern Maine is gradual, and the streams in that region are sluggish; and the general slope of the entire region toward the east is so small that the current of the Saint John river, which drains it, is very moderate. On this slope there are large areas permanently swampy, rapids and falls are not numerous, and no large powers are known. The divide separating it from the southern slope is not high and sharp, but in places is very flat and swampy. The waters of the southwest branch of the Saint John and those of the northwest branch of the Penobscot come in part from the same swamps, a phenomenon which also occurs in other places.

The most important point connected with the topography of the region we are considering, as regards its influence on water-power, is the large number of lakes and ponds which exist, and the enormous facilities for storage. The beneficial effects of lakes are well known, and have already been briefly referred to. Not only do they serve as reservoirs to receive the waters tributary to them and give them out gradually, thus lessening the violence and the suddenness of freshets, and increasing very greatly the flow in dry seasons of the stream below, but they also, when deep, serve to lessen the loss by evaporation by exposing a smaller surface to the rays of the sun, and, moreover, serve to keep the water warm beneath the covering of ice which forms early in the winter, and in this way contribute to lessen the trouble experienced below with ice-jams, floating ice, or anchor-ice. Not only is little ice carried down the rivers from the ponds, but a much smaller quantity is formed below. This element is especially important in a region like New England, where the winters are severe and interruptions due to ice sometimes occur. It is therefore very important to observe that the number of lakes in this district is very large indeed. Wells states that there are connected with the rivers of Maine alone, not counting small ponds and a large number of ponds in the forest region of the state not represented on any map, over 1,620 lakes, covering together, probably, at least 2,300 square miles in area. Of this number, 1,568 are in the state of Maine, covering a total surface of 2,200 square miles, there being one lake to every 20 square miles of territory, and one square mile of lake surface to every 14.3 square miles of territory. In New Hampshire and Massachusetts lakes are not so numerous, but still sufficient in number to be of very great benefit. It is in New Hampshire, in fact, that the lakes are used to the best advantage, as we shall have occasion to show. In the part of this territory not including Maine we may count upon the map several hundred lakes and ponds, covering probably not less than 150 square miles. In regard to these lakes it is important to notice that the larger ones are generally situated near the headwaters of the rivers, at a considerable elevation above the sea. Were there only a few lakes, and near the headwaters of the large rivers, those rivers near their mouths would be subject to quite heavy freshets, for the lakes would only regulate the stream flowing directly from them; but as almost every tributary of the large rivers, from source to mouth, is also provided with lakes, the effect of the large number and elevated position of the lakes is to render the flow of almost all the streams comparatively constant. Not only are there these natural reservoirs, but there are, through all the region considered, excellent facilities for artificial storage. The lakes may, in most cases, easily be converted into storage reservoirs, as is, in fact, generally done for log-driving purposes, and, in addition, artificial ponds may be formed in many places. Wells gives the average depth which can be controlled in the lakes of Maine as not less than 8 feet. The following table, taken principally from his report, will show the elevations above tide of some of the principal lakes in the district treated in this report:

Elevation of a few of the largest lakes.

Lake	Feet.	Lake	Feet.
Moosehead	1,023	Merrymeeting	589
Wood	1,094	Richardson	1,456
Attean	1,094	Mooselucmaguntic	1,486
Long pond	1,094	Rangeley	1,511
Schoodic (about)	300	Mattagamon (about)	850
Sebec (about)	375	Chamberlain	926
Baskahegan (about)	400	Pomgoewahem and Churchill	914
Pamedumcook, the Twins, and Milinoket (about)	500	Allaguash (about)	950
Ripogenus	878	Eagle	579
Chesuncook	900	Square and Cross	587
Cauquomgomoc (about)	930	Long	603
Squawpan (about)	580	Portage (about)	625
Sebago	247	Fish river (about)	660
Umbagog	1,256	Chiputneticook	382
Winnipiseogee	501	Chiputneticook Grand	449
Squam	510	Great East pond	499
Newfound	597	Ossipee lake	408

In order to give an idea of the value of this elevation, we may mention that lake Itasca, at the headwaters of the Mississippi, is only about 1,575 feet above the sea, which is over a thousand miles distant; and that lake Superior is at a height of only 630 feet, though 1,800 miles from the sea. No other district of equal size in the Union, it may be safely asserted, contains so many lakes at such high elevations, the fall to the ocean taking place within its limits. These lakes being large, as well as the streams flowing from them, their effect is to increase very greatly the theoretically available power of the latter.

If we were to sum up in a few words the effect of the topography of this district on the water-power, we should say that it is favorable in every respect, contributing not only to constant flow, but affording numberless falls easily utilized.

4.—Geology; soils, and forests.

Geologically, this district belongs almost entirely in the region of metamorphic rocks. A large part of it is underlaid with granite and allied rocks, which occupy, according to Wells, an area of 13,500 square miles in Maine, comprising the whole region west of the Kennebec, 3,400 square miles being almost exclusively underlaid with granite. In New Hampshire the entire valley of the Merrimack, as well as that of the Saco, is granitic, and large areas in Massachusetts are also underlaid with the same rock. A belt of it extends along the coast of Maine in its whole extent, and large quantities are shipped to other parts of the country. That part of the region not underlaid with granitic rock is underlaid with hard slates and schists, with their strike nearly at right angles to the general course of the rivers, so that the latter tumble over the upturned edges of those strata, and often form falls of considerable magnitude. The most important fact connected with the rocks as regards water-power is their great hardness and their disposition on the southern slopes, where the water-power is for other reasons most favorable. As the streams cross their upturned edges, ledge after ledge, numerous falls, rapids, and cascades are formed in all parts of the region, from the mountains to the sea. These falls are permanent, which would not be the case were the rocks soft, disintegrable sandstone or limestone. Further, not only are good building materials everywhere abundant, but the facilities for the location of mills on solid foundations are unsurpassed.

The soil through the whole of New England is comparatively shallow, and is generally clayey or sandy in character. The rock is much exposed over the whole region, and there is little alluvial soil. Were the rainfall very unevenly distributed through the year, and were there no facilities for storage, this shallowness of the soil would be very unfavorable, and the water would be rapidly shed from the rock surfaces, rendering the streams very variable in flow. But we shall see that the rainfall is very uniformly distributed through the year, though in a way favorable to constancy of flow, and this renders the shallowness of the soil of less detriment. Considerable beds of drift exist in places, but there are few sand-hill streams like those on the coast of New Jersey or in the southern states, there being few or none in Maine and New Hampshire, and only a few small ones in Massachusetts and Rhode Island.

The forests are very extensive in the region we are considering. It is estimated that in Maine there are 19,300 square miles of wilderness, and perhaps 21,200 square miles of woods in all. In New Hampshire the mountains are densely wooded around their bases, though the ridges, and especially the summits, are often bare. In Massachusetts and Rhode Island the woods are less extensive. These woods are located very favorably where they are likely to be long permanent, and being principally evergreen, they shade the ground at all seasons, thus checking evaporation, lessening the violence of winds, and so increasing the amount of water discharged by the streams. For a statement of the effects of forests, reference may be made to the introduction to the Report on the Southern Atlantic Water-shed. Their favorable influence is generally recognized, yet it must be remarked that their destruction would be much less detrimental here than in regions where there are no lakes, where the rainfall is

very unevenly distributed, where the temperature is high, or where the country is more mountainous. Most dense at the foot of the mountains, the woods of New England operate to check the torrents rushing from their rocky sides, and hence to mitigate very essentially their unfavorable effects.

5.—Tidal water-power.

The economical use of tidal water-power requires not only a sufficient rise and fall of the tides, but also a topography along the coast favorable for the location of buildings and for the construction of basins in which to store the water at high tide. In all these respects the coast of New England is more favorable than any other part of the Atlantic coast. The rise of the tide varies from 5.1 feet at Providence to 10 feet at Boston, 8.6 feet at Portsmouth, and 18.1 feet at Eastport, thus increasing quite regularly from south to north, and averaging 11.6 feet on the coast of Maine. South of Maine the average rise for the whole Atlantic coast is only 5.2 feet. Moreover, the coast of New England, especially in Maine, is rock-bound, so that there is no trouble with regard to proper foundations; and finally, the coast-line being very irregular and indented with numberless bays and inlets, there are no difficulties as regards storing the water in sufficient quantity. (*a*) Tidal power is used at a few places in Massachusetts, but principally in Maine, and it is in that state that the conditions are most favorable. It can be used there for sixteen hours out of twenty-four, and is used principally for saw-, grist-, and plaster-mills. There is no trouble with ice, and the facilities for transportation by sea or land are of the best.

6.—Climate.

The principal climatic conditions of the region under discussion, in so far as they affect the water-power, will be briefly given.

(*a*) Coast-line and ocean-currents.—The coast-line, which measures nearly 450 miles, following its general course, is so indented as to make its real length perhaps ten times as large. It is washed by the cold polar current which flows between the coast and the warm waters of the Gulf stream, so that the winds from the east and northeast, though maritime, are cool, while those from the south and southwest are much warmer.

(*b*) Winds.—The winds are variable, rarely blowing from one direction for more than a few days. The prevailing winds, however, are from the west, southwest, or northwest, in all parts of the region. In summer, winds from the southwest are most frequent; in winter, those from the northwest, while winds from between south and east are least frequent of all, occurring principally in summer. The resultant wind for the year, which shows the general direction of the motion of the atmosphere, is always from a point between north and west. In summer the resultant is from south of west, and in winter from north of west.

(*c*) Temperature.—The mean summer, winter, and annual temperatures are quite different in different parts of the region we are considering. The mean annual temperature varies from 40° in the north to 48° or 50° in the south; the mean summer temperature from about 62° in the north to 68° in the south; and the mean winter temperature from 12° or 14° in the north to 28° or 30° in the south. As compared with the middle and southern states, the mean annual temperature is, speaking roughly, from 8° to 15° lower, while the mean summer temperature is from 5° to 10°, and the mean winter temperature 12° to 20° lower. For more extended data we must refer to the Report on the Southern Atlantic Water-shed and the publications of the Smithsonian Institution. The most important point to be noticed is the fact that although the mean annual temperature is considerably lower than that in the middle and southern states, this is due not so much to a lower summer temperature as to a lower winter temperature. The table of extreme observed temperatures which will be given in the Report on the Southern Atlantic Water-shed shows that the highest observed temperatures in Maine and in Alabama are almost the same; and the table of average temperatures of hottest and coldest months, also given in the same report, shows very clearly that there is much greater difference between the coldest months in New England and those in the southern states than there is between the hottest months in those localities. On account of the cold current flowing along the coast of New England the temperature of that region is lower in summer than that of the regions farther inland, while its mean winter temperature is higher, so that the yearly fluctuation is less, as would naturally be expected from its position on the coast. The isothermals run generally parallel to the parallels of latitude, the mean annual temperature decreasing from south to north. Compared with other parts of the country, the annual fluctuation of temperature is greater in New England than in the southern sea-board states, but less than in the inland states. Regarding the winter temperature, the principal point to be noticed is that it is below the freezing point. The severity of the winter in New England is productive of some difficulty in keeping the wheels and canals clear of ice, but this trouble is generally considered to be greater than it really is by those in states more favored in this respect. Indeed, the trouble carries with it its own corrective. Before the lakes and ponds freeze over in the winter some trouble is experienced from floating ice and from anchor-ice, but as soon as they freeze over permanently this trouble ceases, the covering of ice keeping the water warm beneath it. Floating ice may be kept out of the canals by suitable

a The coast-line of Maine, which is 226 miles long in a direct line, measures, with all its indentations, from 2,000 to 3,000 miles.—Wells: *Water-power of Maine*, p. 34.

fenders, but at night it sometimes forms in them, and has to be run out in the morning if it is thick enough to diminish too greatly the capacity of the canals. Anchor-ice, which forms at the bottom of the canals in small particles and rises to the top, filling the races, racks, and flumes with a mass of slush, is sometimes very troublesome, but rarely after the ponds freeze over. On the whole, the interruption due to ice does not generally extend over more than a few days in the year, and in the case of some of the large powers, where pains are taken to prevent it, no trouble at all is experienced in running the machinery all the time. The low annual temperature is favorable in increasing the rainfall and diminishing the evaporation, and so contributing to the flow of the streams, without impairing the habitability of the region. This effect would be greater were the summer temperature lower.

(*d*) RAINFALL.—We have to do here with a part of the country falling under type I, according to the classification followed in the Smithsonian tables of rainfall (*Smithsonian Contributions to Knowledge*, 353, second edition, 1881). The characteristics of this type are the following: "Three nearly equal maxima, about the middle of May, August, and December, and one principal minimum, about the beginning of February; the range between the extreme monthly values is small; the August maximum is generally the highest." The stations from which this type is constructed are 18 in number, extending from Portland to Washington, and are mostly near the coast. The monthly rainfall varies from 0.84 of the mean in February to 1.22 of the mean in August, the fluctuation being, therefore, 38 per cent. of the mean monthly rainfall. In New England alone the fluctuation is rather smaller, or about 34 per cent., the monthly rainfall varying from 0.85 to 1.19 of the mean. In the Hudson River valley it is 60 per cent., in the upper Mississippi valley 105, on the southern Atlantic coast 140, and on the Pacific coast 232 per cent. From the fluctuation alone, however, no conclusions can be reached regarding the flow of the streams, for this depends upon the season when the rainfall is greatest, as has already been indicated. It is important to notice, however, that the fluctuation in New England is less than in any other part of the country, or that the rainfall is more uniformly distributed through the year. The fluctuation seems to increase a little as we go north in New England, and also as we recede from the coast, being, in some places distant from the coast, nearly or quite twice as great as given above; still, it is nevertheless true that in no part of the country is the rainfall so uniformly distributed through the year as in that with which we have now to do.

As regards absolute amount, the mean annual rainfall varies from between 44 and 50 inches along the coast and over almost the whole of Connecticut, Rhode Island, and Massachusetts, to 38 inches in the north of Maine and New Hampshire, diminishing as the coast is receded from. The rainfall averages, speaking roughly, about 11 inches in spring, 11 in summer, 12 in autumn, and 10 in winter, except near the coast, where it is more uniform.

The annual rainfall is subject to an extreme fluctuation of about 50 per cent. of its mean value, this being about as small as in any other part of the country. Very dry or very wet years are therefore not to be often looked for. We see, therefore, that both from year to year and from month to month the rainfall is about as evenly distributed in this district as in any other part of the United States. The small excess in summer and autumn is favorable to a constant flow of the streams, and would be very important, in view of the shallow soil, were there no facilities for storage.

Snow falls to a considerable depth over the whole region in question, and in the mountains does not disappear till late in the spring, remaining on the ground even all the year in some parts of New Hampshire. The mean annual depth of snow at seven stations in Maine has been found to be about 83 inches, but in the other states it is less. The fact that in winter nearly all the precipitation is in the shape of snow has an important effect on the flow of the streams. When the ground freezes it becomes nearly impervious to moisture, so that during the winter almost all the water reaching the streams is that derived from springs, fed by rains of the earlier months, and that due to the melting of the snow, which runs directly from the ground. If the snow stays on the ground all winter, with no warm periods sufficient to melt much of it, the streams are apt to run very low. If, on the other hand, the snows are liable to be carried off suddenly by short periods of warm weather, the streams will be subject to severe freshets. In this district, and especially in the northern part of it, the snows remain on the ground all winter, and, protected by the forests, they often are dissolved very gradually before the approaching heat of summer, and disappear much less suddenly than in the middle states. Though the rivers in both regions are subject to spring freshets when the snow goes off, those in this district are in general less sudden and severe than those on streams farther south, and they are less liable to be accompanied by ice-jams, because the ice on the lakes does not go out until it has become melted to such an extent as to be rotten and of little danger, while the streams below them, as has been remarked, are not so liable to have large masses of floating ice. Though the streams are subject to a winter drought, that drought is, in general, not so severe as that which occurs in summer, and is therefore not detrimental to the use of power. The fact that the freshets and ice-jams are not so severe here as in the states farther south is one of great importance. Rises of 60 feet, such as occur on some of the western and southern streams, are unknown here, and even the greatest recorded rise of the Connecticut at Hartford (29½ feet) has not often been reached on any of the streams we are to consider.

Another favorable feature of the district is the prevalence of fogs, which are particularly frequent in Maine. The dense fogs formed off the banks of Newfoundland are brought in by the northeast winds, and often involve, for weeks at a time, a considerable portion of the state, especially during the latter part of summer. Fogs, in fact, are generally associated with rain in Maine, the latter falling generally quite gradually, and not so much in sudden

showers as in the states farther south. These facts are important, because where rain falls gradually it is not shed from the surface so rapidly, but has more chance to be retained in the ground and discharged gradually; and where fogs prevail evaporation is diminished, because the air is cool and moist, and the rays of the sun are intercepted. This is especially important, as the fogs prevail in summer.

7.—Flow of streams.

We have discussed already the general principles governing the flow of streams, and also the effect exerted on the flow by the various general circumstances connected with the district. It is, therefore, only necessary here to show how the estimates given in the following pages have been made.

In the Report on the Southern Atlantic Water-shed reference is made to the fact—which follows clearly enough from what has been said already in this report—that it is not correct to assume any fixed proportion of the annual rainfall as discharged by the streams. In the following report estimates are given of the following four quantities regarding flow:

1. The absolute minimum flow.
2. The minimum low-season flow.
3. The maximum flow with storage.
4. The low-season flow in dry years, but not the driest.

The absolute minimum flow can only be estimated by comparison with results of gaugings on other streams, a number of which are given in the table on page 9. In estimating it, it is best to assume the number of cubic feet per second per square mile of water-shed, and all the circumstances detailed as affecting the distribution of flow have to be taken into account. The minimum flow is of course all that can be depended upon permanently, but it occurs at such rare intervals that it is generally advisable to utilize a larger amount, even if there is a deficiency at times.

The low-season flow in any year is the flow during the period, of from three to eight weeks, when the stream is lowest. This flow is different in different years, and its minimum value occurs only at intervals of a number of years. In ordinary years the flow will at all times be greater than the minimum low-season flow, except, perhaps, for a day or two; in very dry years it may be less than the minimum low-season flow for several weeks at a time. The minimum low-season flow has been estimated in the following way: It has been found by the experience of cities in regard to their water-supply, and by continued gaugings of streams, that in very dry years, in this climate, the total amount of rainfall discharged by streams falls as low as from 12 to 15 inches over the entire drainage basin. In ordinary years a larger quantity is discharged, but at intervals of from five to ten years a very dry year occurs, when the total flow does not exceed 12 or 15 inches over the water-shed. Having assumed an annual flow of from 12 to 15 inches, then, by dividing it by 12, we obtain the average flow per month, in inches on the water-shed. Now, 1 inch on a square mile, flowing off in a month, would give an average flow of 0.884 cubic feet per second; so that by multiplying by 0.884 the average flow in inches per month, we have the average flow, in a very dry year, in cubic feet per second per square mile.

It is now necessary to have some data regarding the way in which the flow varies from month to month, and in regard to this some figures are collected and shown in the table on page 10. By multiplying the average flow obtained above, by the ratio which the flow in any month bears to the mean—that ratio being reached by a study of the last-mentioned table, bearing in mind all the local circumstances—we obtain the flow in that month in the year in question. The minimum low-season flow, though not to be depended upon permanently, may be rendered so by a small amount of artificial storage. It is generally advisable to utilize a larger flow, even though there may be a deficiency at intervals.

The minimum low-season flow occurs in the driest year, but not necessarily the year of least rainfall, because it is not the amount of rainfall alone that affects the flow. Assuming, however, as close enough for practical purposes, that the amount of flow in a year will vary directly with the rainfall, and that the year of the minimum low-season flow will be the year of minimum rainfall, we may estimate the low-season flow in other years by proportioning it to the rainfall. The Smithsonian tables show that the minimum annual rainfall is about 0.7 of the mean, and the maximum about 1.3 of the mean; and, further, that the rainfall in ordinarily dry years, but not the driest, is about 0.8 of the mean. Having found, therefore, the minimum low-season flow, we may approximate to the low-season flow in ordinarily dry years by taking eight-sevenths of it, and to that in ordinary years by taking ten-sevenths of it. Further, these remarks, in connection with the table of monthly distribution of flow, will enable any one to estimate the flow during any number of months in any year. The local circumstances, however, must be carefully studied, and upon the judgment shown in taking them into account will depend the accuracy of the estimates.

If sufficient storage is available the average amount of water discharged in any year may be utilized, the quantity in excess of the average being stored up and delivered in times when the natural flow is less than the average. The quantity which can be depended upon permanently, however, is evidently that which flows off during the driest year, or the smallest quantity which flows off in a year; *i. e.*, 12 or 15 inches, according to what has been said above. By building storage reservoirs of sufficient capacity, then, we may utilize permanently a quantity equal

to 12 or 15 inches in a year over the whole drainage area, flowing off uniformly. By dividing this by 12 and multiplying by 0.884 we obtain the number of cubic feet per second per square mile of water-shed. The amount of storage necessary to render this quantity available has been found by experience to be 3 or 4 inches in depth over the entire water-shed. With small drainage areas the maximum with storage may be utilized, but with drainage areas over a few hundred square miles in area the storage necessary is so large that unless specially favorable circumstances are present, such as lakes which may easily be converted into artificial reservoirs, the storage necessary could not be economically provided for. In the case of large streams, then, the maximum with storage is of small importance. In many cases the flow can be materially regulated, but not to such an extent as to render the absolute maximum available.

I will recapitulate here briefly the meaning of the four quantities estimated:

1. ABSOLUTE MINIMUM FLOW: May be depended upon always, without storage; occurs only at rare periods; generally a large excess.

2. MINIMUM LOW-SEASON FLOW: Flow in the low season of driest year; may be depended upon, without storage, at all times except for a few days in the dry season of each year, when there may be a deficiency; with small storage, may be depended upon all the time.

3. MAXIMUM FLOW WITH STORAGE: Mean flow in driest years; storage already discussed; with larger storage, more could be utilized for several years, but not permanently.

4. LOW-SEASON FLOW IN ORDINARY DRY YEARS, without storage: May be depended upon except in the dry season of each year, when for a few days, perhaps weeks, there may be a deficiency; may be rendered permanently available by storage. This last quantity is the most important of the four, yet in each particular case it is a special problem to decide how much power may be economically utilized.

The following are the tables referred to:

Extremes of flow for some American streams.

River.	Place.	Drainage area, square miles.	Mean rainfall, inches.					Remarks on character of drainage basin.	Extremes of flow.			Minimum, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	Authority and remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.		Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.			
Merrimack	Lowell	4, 085	10	11	13	9	43	Lakes and artificial reservoirs. Wooded.	81, 000	1, 275	64	0. 31	....	
Merrimack	Lawrence	4, 599	10	11	13	9	43	......do	96, 000±	1, 400	70	0. 31	....	
Concord	Lowell	361	11	11	12	10	44	Stream sluggish and swampy. Few woods. Hilly and rolling. Some reservoirs.	4, 449	59. 84	74	0. 17	....	C. Herschel.
Sudbury	Framingham	78	11	11	12	10	44	Hilly and swampy. One-sixth to one-eighth wooded.	3, 228	2. 80	1, 153	0. 036	....	A. Fteley.
Charles	Newton Upper Falls.	215	11	11	12	10	44	Hilly and rolling	....	44	......	0. 20	....	J. P. Kirkwood.
Hale's brook, Mass.	....	24	11	11	12	10	44	....	....	3. 24	......	0. 135	....	J. P. Frizell.
Connecticut	Hartford	10, 234	10	12	12	10	44	Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.	207, 443	5, 219	40	a 0. 510	....	T. G. Ellis.
Connecticut	Dartmouth	3, 287	10	12	12	10	44	......do	....	1, 006	......	0. 306	....	C. Herschel.
Housatonic	....	790	12	12	12	10	46	....	....	130	......	0. 165	....	H. Loomis, Report New York Committee Public Works, 1879.
Croton	....	338. 82	12	13	13	10	48	....	25, 367	50. 80	500	0. 150	....	J. J. R. Croes and G. W. Howell.
Croton, West branch.	....	20. 37	12	13	13	10	48	Very broken and undulatory. Hills steep and rocky. Largely wooded. Little cultivated.	1, 109	0. 407	2, 722	0. 020	....	J. J. R. Croes.
Passaic	Paterson	813	12	14	12	10	48	Some lakes and swamps. Hilly.	....	178	......	0. 22	....	J. J. R. Croes and G. W. Howell.
Do.	Belleville	962	12	14	12	10	48	......do	19, 944	225. 60	88	0. 023	....	Do.
Delaware	Lambertville	6, 500±	11	13	11	9	44	Hilly and rolling. Many lakes. Well wooded.	350, 000	2, 000	175	0. 300	....	Ashbel Welch.
Schuylkill	Philadelphia	1, 800	12	14	10	9	45	Hilly and rolling. No lakes. Some reservoirs.	....	307 to 378	......	0. 17 to 0. 21	....	E. F. Smith and H. P. M. Birkinbine.
Hackensack	....	84	12	14	12	10	48	Flat. No lakes or reservoirs, except mill-ponds.	....	27	......	0. 33(?)	....	C. D. Ward.
Ohio	Pittsburgh	19, 900	10	12	9	10	41	Hilly and mountainous. No lakes. Wooded.	....	2, 271	......	0. 114	....	J. H. Harlow.

a Since the date of Ellis' measurements the flow of the Connecticut has been as low as between 0.25 and 0.30 cubic foot per second per square mile, on good authority.

Extremes of flow for some American streams—Continued.

River.	Place.	Drainage area, square miles.	Mean rainfall, inches. Spring.	Summer.	Autumn.	Winter.	Year.	Remarks on character of drainage basin.	Extremes of flow. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.	Minimum, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	Authority and remarks.
Potomac	Cumberland	920	10	12	9	8	39	Narrow valleys. Steep slopes. Wooded. No lakes.	17,900	25	716	0.022	......	W. R. Hutton and Patterson.
Do	Dam No. 5	4,640±	11	12	9	8	40	......do	92,772	363	255	0.0783	......	Quoted by W. R. Hutton.
Do	Great Falls	11,476	12	13	9	8	42	Country more open. No lakes.	175,000	1,063	165	0.093	......	W. R. Hutton.
Rock Creek	Hoyle's mill	64.40	11	12	11	8	42	......	......	7.50	......	0.114	0.458	Quoted by W. R. Hutton.
Kanawha	Charleston pool.	8,900	12	13	9	10	44	Mountainous. Steep. No lakes. Wooded.	120,000	1,100	110	0.123	......	Gill, Scott, and Hutton.
Greenbrier	Mouth of Howard's creek.	870	11	12	8	9	40	......do	......	97	......	0.120	......	McNeill.
Shenandoah	Near Port Republic.	770	12	13	8	8	41	Hilly. Limestone. No lakes. Many springs.	......	128	......	0.167	......	James Herron.
James	Richmond	6,800	12	12	9	10	43	Mountainous in upper part. No lakes. Wooded.	......	1,300	......	0.191	......	H. D. Whitcomb and W. E. Cutshaw.
Neuse	Near Raleigh	1,000	12	13	10	10	45	Open. Clay and loam. No lakes. Few extensive woods.	......	......	......	......	0.193	W. C. Kerr. Low-water.

Monthly distribution of flow.

FLOW IN DRY YEARS.

Rivers.	Drainage area, square miles.	Flow in inches on water-shed. Driest month.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.	Total for the year.	Ratio of monthly to mean flow. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.
Croton	339	0.20	0.35	0.53	0.63	0.87	0.94	1.52	1.63	1.80	1.90	2.08	2.27	14.72	0.16	0.29	0.43	0.51	0.71	0.77	1.24	1.33	1.47	1.55	1.70	1.85
Concord	361	0.25	0.32	0.36	0.43	0.54	0.68	0.85	1.07	1.36	1.70	2.15	3.62	13.33	0.22	0.29	0.32	0.39	0.49	0.61	0.76	0.96	1.23	1.53	1.94	3.26
Merrimack	4,599	0.68	0.70	0.77	0.85	1.00	1.13	1.30	1.53	1.98	2.55	3.22	5.42	21.13	0.38	0.40	0.44	0.48	0.57	0.64	0.74	0.87	1.12	1.45	1.83	3.08
Connecticut	10,234	0.65	0.68	0.71	0.74	0.88	0.90	1.28	1.51	1.80	2.02	3.28	4.71	19.16	0.41	0.43	0.45	0.46	0.55	0.56	0.80	0.95	1.13	1.26	2.05	2.95
Schuylkill (*a*)	1,800	0.27	0.30	0.38	0.40	0.53	0.62	0.68	0.79	0.88	0.98	1.08	1.59	8.50	0.38	0.42	0.54	0.57	0.75	0.88	0.96	1.12	1.24	1.38	1.52	2.24
AVERAGE FLOW FOR A SERIES OF YEARS.																										
Croton	339	0.56	0.95	1.12	1.21	1.43	1.82	2.30	2.57	2.77	3.02	3.60	4.00	25.35	0.26	0.45	0.53	0.57	0.68	0.86	1.09	1.21	1.31	1.43	1.70	1.90
Concord	361	0.39	0.46	0.51	0.61	0.76	0.96	1.25	1.52	1.92	2.38	3.00	4.86	18.62	0.25	0.30	0.33	0.39	0.49	0.62	0.81	0.98	1.24	1.53	1.93	3.13
Merrimack	4,599	0.77	0.88	1.06	1.26	1.52	1.80	2.12	2.49	3.03	3.73	4.63	6.56	29.85	0.31	0.36	0.43	0.51	0.61	0.72	0.85	1.00	1.22	1.50	1.86	2.63
Connecticut	10,234	0.75	0.85	0.91	1.10	1.34	1.58	2.00	2.36	2.81	3.27	4.52	6.26	27.75	0.33	0.37	0.39	0.47	0.58	0.68	0.87	1.02	1.21	1.41	1.96	2.71
FLOW IN DRY YEARS OF STREAMS OF SMALL DRAINAGE AREA.																										
Cochituate	19.00	0.08	0.41	0.46	0.47	0.70	0.88	0.97	1.03	1.11	1.31	1.47	2.26	11.15	0.09	0.44	0.50	0.51	0.75	0.95	1.03	1.11	1.20	1.41	1.58	2.43
Croton, West branch	20.37	0.10	0.17	0.46	0.53	0.67	0.84	0.98	1.02	2.31	3.37	3.41	5.40	19.26	0.06	0.10	0.28	0.33	0.42	0.52	0.61	0.64	1.44	2.10	2.13	3.37
Sudbury	78.00	0.11	0.16	0.25	0.39	0.57	0.79	1.06	1.40	1.79	2.21	2.77	5.09	16.59	0.08	0.11	0.18	0.28	0.41	0.57	0.77	1.01	1.29	1.60	2.01	3.69
Passaic headwaters	50–100	0.11	0.15	0.21	0.27	0.49	0.67	0.90	1.22	1.77	1.87	2.13	3.65	13.44	0.10	0.13	0.19	0.24	0.44	0.60	0.80	1.09	1.58	1.67	1.90	3.26

a Charles G. Darrach, in *Engineering News*, April 3, 1880, p. 122.

9.—RÉSUMÉ.

Reviewing what has been written in the previous pages, the topography and the geology of the region, affording a rapid declivity from the mountains to the sea, broken by sudden falls over ledges of hard rock; the favorable character of the bed and banks as regards foundations and freedom from overflow; the favorable arrangement and small extent of the mountain region; the low temperature, causing a large rainfall and a small evaporation; the favorable distribution of the rainfall through the year; the immense facilities for storage; the extensive forests; the absence of very destructive freshets and ice-jams; the rock-bound coast, affording facilities for utilizing the large rise of the tide; the prevailing fogs; and the accessibility of the region, together constitute an array of favorable circumstances which may well entitle New England to the first rank as a water-power district, as the detailed account of the different streams will show.

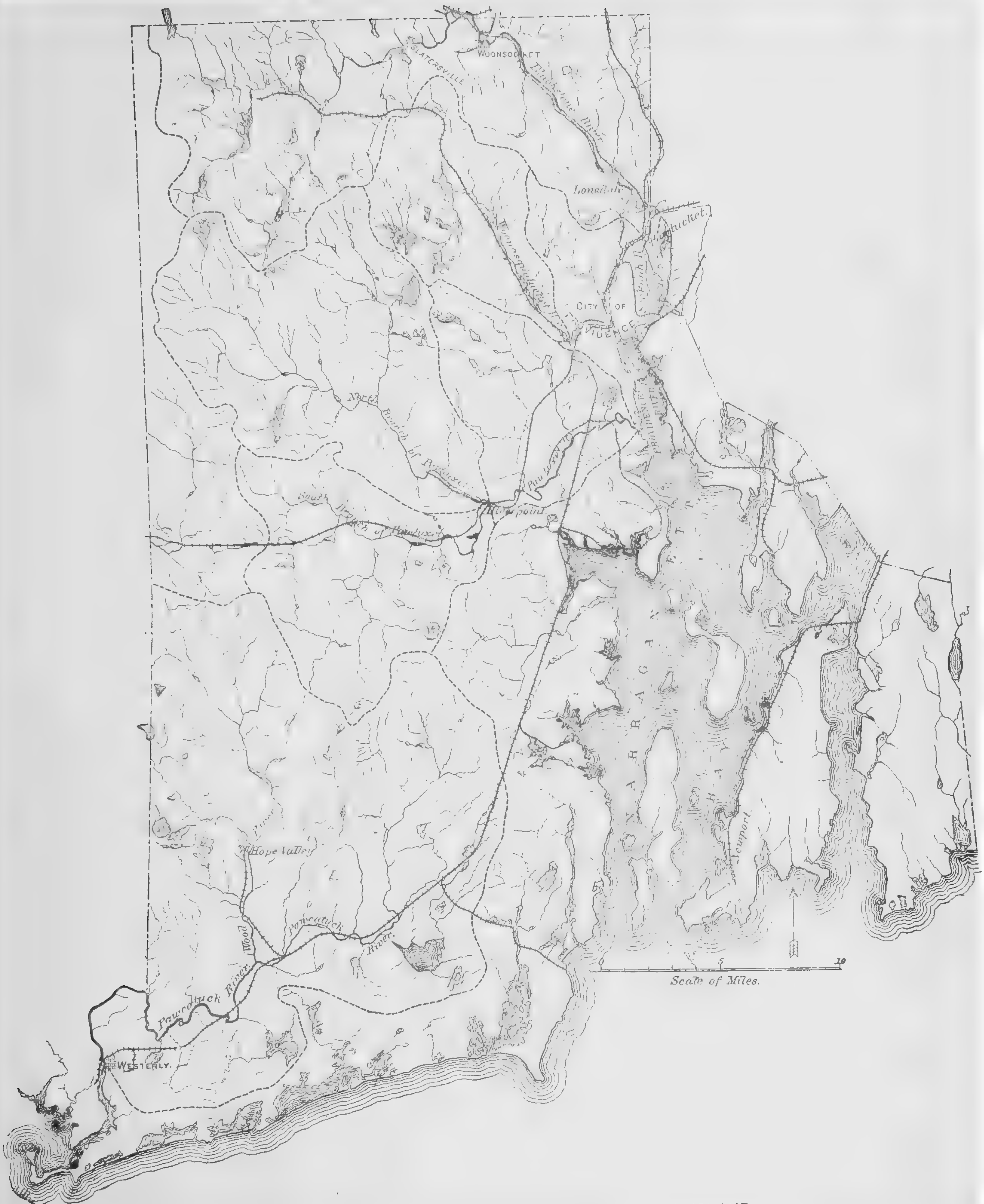

Fig. 1. MAP OF THE DRAINAGE BASINS OF RHODE ISLAND.

Fig. 2. MAP OF THE DRAINAGE BASINS OF EASTERN MASSACHUSETTS.

II.—THE COAST STREAMS SOUTH OF THE MERRIMACK.

The streams flowing into the Atlantic between the Merrimack and the Connecticut possess no true mountain district, but are confined entirely to the middle division, or Atlantic plain, which covers Rhode Island and eastern Massachusetts. Nevertheless, their fall is quite rapid, and lying, as they do, close to the most populous cities of the region and within easy reach of railroad communication, they have been utilized for power for many years, and privilege after privilege has been improved, until scarcely any are left idle. By a system of reservoirs their flow has been rendered in many cases much more uniform than it otherwise would be, so that some of them afford a large number of excellent powers. The rainfall over the whole region is about 45 inches, very evenly distributed through the year, nearly the same amount falling in each season.

We will describe the streams in order, commencing at the south. Passing over the Mystic river and several other small streams not worthy of a description, the first stream which is to be noticed is,

THE PAWCATUCK RIVER.

This stream takes its rise in the southern part of Kent county, Rhode Island, and pursues first a southerly course, for a distance of about 12 miles, in a straight line, under the names of Queen's and Usquebaug rivers. Turning to the west, it then pursues a tortuous course in a general southwesterly direction for about the same distance, when it reaches tide-water, at Westerly, Rhode Island, about 5 miles from Long Island sound. The stream is small, draining only about 286 square miles, comprising a considerable extent of flat and swampy country, while the rest is hilly and rolling. The only town of much importance through which it flows is Westerly, the head of navigation. The drainage area is not well wooded, and there are few lakes. Some artificial reservoirs, however, together with the swamps, serve to restrain the violence of the floods, and suffice, with the mill-ponds, to regulate the flow to some extent, making the stream quite a good one for manufacturing. Its bed and banks are in places rocky, but are generally of sand or gravel, the stream, in fact, partaking to some extent of the character of a sand-hill stream. Its fall is not large, but is completely utilized. It is not subject to severe freshets, and little ground, outside of the swamps, is overflowed, a rise of 3 feet being seldom exceeded. The character of the drainage basin is not such as to favor the rapid discharge of storm waters, and the regulating effect of the swamps and mill-ponds is considerable.

The first power on the stream is at Westerly, where the rise and fall of the tide is about 4 feet, and up to which place boats drawing nearly 7 feet ascend. A wooden dam $5\frac{1}{2}$ feet high ponds the water half a mile, affording at low tide a fall of $5\frac{1}{2}$ feet. Power is used on both banks, on the left by the Stillman Manufacturing Company's woolen-mill, with 50 or 60 horse-power during about eight months, while at other times the power is almost nothing; and on the right bank by the Carmichael Manufacturing Company (machine-shop and woolen-mill), using about 100 horse-power during about six months. The mills have steam in reserve.

Above Westerly there are a number of woolen- and cotton-mills on the stream, all the sites of importance being occupied. Reliable data regarding the power of these mills are not at hand. The power used, however, is much in excess of that afforded during the low season, so that generally steam-power is in reserve, and water-power alone is not depended upon. The mill-ponds suffice to store the water at night in dry seasons, but the swamps, not being controlled, are not very efficient as regulators of flow during the year, except in diminishing the violence of freshets. Full capacity is not generally secured for over nine or ten months.

Of the tributaries of the stream only one is worthy of remark. Wood river, which has its sources in Kent county, flows nearly south through a distance of about 15 miles, joining the Pawcatuck at Plainville. It drains about 83 square miles, and resembles the main river in all essential respects. Like it, it is utilized by various mills, but in dry weather the power is very small, and the mills have to use steam or stop running. The stream has a few unutilized privileges, but none of much value.

Of the lakes and ponds connected with the Pawcatuck none are dammed and used for storage except some on Wood river. Wordin's pond, which comes in above Holberton hill, is the largest sheet of water, and is connected with swamps of considerable size. In addition to this, Pasqueset, Watchaug, and School-house ponds, and two near Kingston, are not used. Connected with Wood river are some small ponds used as reservoirs, of which a few may be mentioned: Yawcoog pond covers from 500 to 550 acres when full, and can be drawn down about 16 feet, containing sufficient water to run a mill below for some three months; and Wincheck pond, just below, but above the mill, is said to cover some 400 acres, and can be drawn down $5\frac{1}{2}$ or 6 feet. Both of these ponds are controlled by the mill at Rockville. Blue pond, on another branch, covers some 200 acres, and Long pond is smaller; besides which there are other and still smaller ponds. In addition, there are some small ponds on a small stream joining the Pawcatuck at Laureldale. The only sites not used are a few small ones on some of the tributaries of the main stream.

THE PAWTUXET RIVER.

This stream has two branches, the North and the South, the latter of which rises in the western part of Kent county, and pursues a generally easterly course for about 10 miles, to Riverpoint, where it meets the North branch, which has its sources in Providence county, and pursues a southeasterly course, draining a basin about 16 miles long. From Riverpoint the main stream pursues a northeasterly course for about 8 miles, emptying into the Providence river at the village of Pawtuxet, or about 5 miles below Providence. The area drained by the North branch is about 108 square miles; by the South branch, about 71 square miles; by the main stream at its mouth, about 229 square miles. The drainage basin is undulating or hilly, the fall of the stream considerable, the bed and banks are gravel, rock, and sand, the banks not often subject to overflow, and the storage facilities good. The entire fall is utilized, principally by cotton-mills, there being no unimproved sites of importance on either branch. The flow of the stream is variable, yet not to a great extent. Indeed, the stream is called one of the most permanent in Rhode Island, and there is no trouble whatever with freshets. Numbers of artificial reservoirs are connected with the stream, and are used for the benefit of the mills. The following is the information I have been able to collect regarding them:

1. Almy reservoir, Simmons' upper and lower reservoirs, connected with Pochasset river, a tributary of the main river. These are small ponds, and no further data are at hand regarding them.

2. Connected with the South branch:

a. Tioga reservoir, in the southeastern part of the town of Coventry, emptying into the South branch between Washington and Anthony. This reservoir covers about 200 acres and can be drawn down 14 feet, but is not used for power. It is opened every morning and shut every evening.

b. Carr pond, in the town of West Greenwich, joining the South branch between Washington and Coventry Center, covers about 100 acres, and can be drawn down 8 feet; allowed to flow continually.

c. Flat River reservoir, on the South branch, between Washington and Coventry Center, covers 1,000 acres, and can be drawn down 12 feet; opened every morning (except Sunday).

d. Coventry Center reservoir, above Coventry Center, covers about 300 acres; can be drawn down 8 feet. Average depth, about 6 feet.

e. Quidnick reservoir, in the town of Coventry, at the head of the stream, covers some 980 acres, (*a*) and can be drawn down 15 feet. Estimated capacity, 288,159,400 cubic feet; built in 1872 and 1873.

3. Connected with the North branch:

a. Westeonnaug reservoir, in the town of Foster, covers about 150 acres; can be drawn 13 feet; comes into Ponaganset river between Richmond and Ponaganset.

b. Ponaganset reservoir, at head of Ponaganset river, in the town of Gloucester, covers 225 acres; can be drawn down 25 feet (?).

c. Moswansicut pond, in the towns of Scituate and Johnston, on the Scituate river, covers about 550 acres; can be drawn down 8 feet.

These reservoirs have increased the low-water flow of the stream by a very large proportion. It is proposed to build a new one on the Ponaganset, in the town of Scituate, where it is estimated that a dam 14 feet high could be erected.

The first power on the Pawtuxet river is within half a mile of its mouth, or about 24 miles from the sea. The power, however, is very small. Above it there are two cotton-mills below the junction of the two branches, using a total fall of 25 feet. The mill at Pontiac has a fall of only 5 or 6 feet, while that at Natick has a fall of 20 feet and 700 horse-power. Both mills, however, have engines in reserve.

On the South branch there are some eight cotton-mills, with a total fall of 142 feet, and, in all, nearly 2,500 horse-power. The lowest mills are two of the Green Manufacturing Company, using, respectively, 8 feet fall and 100 horse-power, and 20 feet fall and 125 horse-power. These mills use no steam-power, and are therefore sometimes obliged to stop on account of low water, being only able to run at full capacity about ten months, with no waste at night. The mills above generally have steam-power in reserve. The water is well husbanded, there being no waste for months at a time in dry weather. No trouble is experienced with ice or freshets, 4 feet being a large rise. There are two small powers on this branch said to be not in use at present, though improved.

The North branch resembles the South branch, and, like it, is utilized almost completely, principally by cotton-mills, of which there are a large number on the stream and its various tributaries. The bed and banks are generally rocky where there is any fall. On the upper part of the stream and on its tributaries there are several small powers not used, but none of consequence. The flow of the stream is tolerably uniform, 4 feet being a very large rise in a freshet, as on the South branch; still, the latter is said to be more regular. From the Ponaganset reservoir to tide the fall is said to be 240 feet. Some idea of the capacity of the stream may be obtained from the following data: At the Clyde print-works, the lowest power on the stream, a wooden dam 7 feet high, with a canal of 800 feet, affords a fall of 14 feet, and 240 horse-power are obtained during nine or ten (?) months, there being no waste at night. Steam-power is in reserve, as is the case with almost all the mills on the stream.

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a According to another statement, this pond is "a mile long by five-eighths of a mile wide".

At the cotton-mill of the Lippitt Company, the next above, the fall is 14½ feet, although the available fall between its dam and that below is said to be 17 feet. A power of 150 or 200 horse-power is obtained during about eight months, steam being in reserve. In dry weather there is no waste, and the power runs down to 50 or 75 horse-power.

The Pawtuxet river is one of the best utilized and improved streams in this district. From a comparatively small stream, by judicious reservoiring, a large amount of power is obtained.

THE WOONASQUATUCKET RIVER.

The Woonasquatucket is a small stream, its most distant sources lying in Providence county, about 12 miles northwest of the city of Providence, and its drainage area measuring only about 72 square miles. Its general course is southeast, and it empties into the Providence river at the city of Providence, through which it flows. It drains a hilly and rolling country, and its fall is very large. Notwithstanding its small size, it is of considerable importance as a manufacturing stream, principally on account of the large reservoirs near the headwaters, which are controlled in the interests of the mills below, and regarding which the following facts have been obtained:

1. The Waterman reservoir, covering 318 acres when full, has an average depth of about 9 feet, all of which may be drawn off. It was built nearly fifty years ago, and is controlled by the Woonasquatucket Reservoir Company, consisting of the mill-owners below.
2. The Slack reservoir, emptying below the Waterman, covers 153 acres, with an average depth of about 10 feet. It was built about sixty years ago, and is controlled by the Bernon Manufacturing Company.
3. The Sprague reservoir, controlled by private parties, covers 95 acres, with an average depth of 9 or 10 feet.
4. The Hawkins reservoir, on a tributary, and controlled by private parties, covers 30 acres, with an average depth of 10 feet.
5. The Georgiaville reservoir, or pond of the Georgiaville mills, covers some 130 acres, and is drawn down several feet. It is said that these reservoirs hold about three months' supply for the mills below. By means of them this comparatively insignificant stream has been transformed into an excellent source of power, and almost its entire fall is now utilized, principally by cotton- and woolen-mills, there being no good sites not used. According to the census returns there are, in all, 12 mills on the stream, using a total fall of 204 feet and a total power of 1,374 horse-power. The fall of the stream below the Waterman reservoir is probably not less than about 15 feet per mile. The bed and banks of the stream are generally gravelly, but sometimes rocky, and the freshets very slight, the flow being comparatively constant for so small a stream. Nevertheless, most of the mills have steam-power in reserve, for use in dry seasons. The stream is one of the best examples of what may be accomplished by a system of reservoirs, although, being so small, its flow in very dry seasons is almost nothing.

THE BLACKSTONE RIVER.

This stream, the most important one south of the Merrimack, has always been renowned as a source of power, and it probably turns more spindles than any other stream of equal size in New England. Rising in Worcester county, Massachusetts, near the city of Worcester, it pursues a course southward and eastward, passing into Rhode Island, and emptying into the Providence river at Providence. In the lower few miles of its course, below Pawtucket, it is known as the Seekonk river. It passes in its course the towns of Millbury, Uxbridge, Blackstone, and others in Massachusetts, and Woonsocket, Lonsdale, Pawtucket, and others in Rhode Island, the latter being at the head of tide and of navigation. The length of the stream from its source to Pawtucket, measured in a straight line, is about 38 miles, and its drainage area above that point measures about 458 square miles, comprising a hilly and rolling country, not very well wooded, and with good facilities for storage. Though there are no large lakes in the basin, there are numerous small ponds and reservoirs used for storage, so that the stream may be said to be very well reservoired, and its flow is much more constant than it otherwise would be. The freshets are never severe enough to do any damage, and the low-water flow is very large for a stream of its size. The bed and banks are in every way favorable for power, being often rocky, and there being few low grounds subject to inundation. The valley is entirely free from limestone, the rocks being almost wholly granitic, particularly about the headwaters. The fall of the stream is considerable, and there are a number of natural falls, but every available site has long been utilized; and although at first water-power was depended on, the mills have gradually increased the amount of power used, until now they are obliged to use considerable steam in the dry season, and in some cases all the time. The large number of ponds and reservoirs and the great number of mill-ponds enable the entire flow of the stream during the dry season to be utilized during working hours. The mills are principally woolen- and cotton-mills, and the stream is closely followed for its entire length by a railroad, so that every point is easily accessible. At the mouth of Mill brook, at the city of Worcester, the river has an elevation above tide of 438 feet, and its course below that point measures about 42 or 43 miles, so that its fall is not less than 10 feet to the mile, which is very considerable.

Commencing at the mouth, the various powers on the stream will now be considered.

The first is at Pawtucket, Rhode Island, where there are two dams. The lower one is 6 feet high, or less, and affords a fall of about 18 feet. The power afforded is used on both sides of the stream, half being owned on each side. On the east side is D. Goff & Sons' braid-mill, with $\frac{42}{64}$ of the power, or from 200 to 250 horse-power, and the Bridge Mill Paper Company, with $\frac{22}{64}$, or about 100 horse-power. On the west bank there are no large concerns, but a number of small ones, the power being rented. No pains are taken to divide the water accurately, but full capacity can generally be obtained. The second dam, only a few hundred feet above the lower one, is 7 feet high, and ponds the water for three-quarters of a mile. It is used on the east bank by the Dexter Yarn Company, owning $\frac{16}{64}$ of the entire power, and the "White mill", let to various tenants, with $\frac{13}{64}$ of the entire power. On the west bank are the "old Slater mill", a yarn-mill, the upper floor being let to small establishments at about $100 per horse-power, and the total power being $\frac{15}{64}$ of the entire power; a second mill, let to different tenants, owning $\frac{10}{64}$ of the whole; and Littlefield Brothers' thread- and yarn-mill, with $\frac{10}{64}$ of the whole power. The fall at all the mills is 82 inches, and the distribution of the water is effected by proportioning the apertures to the quantity owned. The mills run eleven hours daily, and can generally run all the year. In addition to the mills mentioned, two other mills on the west bank obtain water from the upper dam, taking their water, of which they are entitled to 23 cubic feet per second, through a separate canal 500 feet long. The first mill is let for various purposes, and uses a fall of 8 feet, the second taking the same water and discharging it below the lower dam. The power at Pawtucket is so divided up among a number of small establishments that no accurate statement of the power used can be made.

The next power is at Central Falls, where power is used on the west bank, with a fall of 10 feet, there being the following privileges: Stafford Manufacturing Company, cotton-mill, owning $\frac{112}{288}$ of whole power, or about 240 horse-power; a privilege belonging to the Andrew Jenks estate, not occupied, owning $\frac{24}{288}$; Thurber, Horton & Wood's cotton-mill, with $\frac{56}{288}$; Central Falls woolen-mill, with $\frac{36}{288}$, and the Pawtucket Haircloth Company, with $\frac{60}{288}$ of the whole. The total power used is stated at 450 horse-power, and the distribution of power is effected by regulating the sizes of the apertures. Full capacity can only be obtained during ten months or so, and some steam is in reserve. (*a*)

The next power is that at Valley Falls, where there is a cotton-mill on each side of the river. The dam is of stone, 9 feet high; the fall used, 13 feet, and the power, about 600 horse-power, during nearly the whole year. Next comes the large power at Lonsdale, where the fall is about 12 feet, and both steam- and water-power are used; then the mill at Ashton, 3 miles above, belonging to the same company, with about the same fall. Part of the water from the Ashton pond is carried by a canal on the west bank of the river down to Lonsdale, and used there with a fall of about 23 feet. The cotton-mill at Albion has a fall of about 14 feet, with 560 horse-power used, and rather more available at almost all times. At Manville a large cotton-mill uses a fall of 18½ feet, with 1,750 horse-power during nine months. The Hamlet mills, next above, use about 10 feet. At Woonsocket is one of the most important privileges on the river. There are two dams. The upper one, called the Globe dam, is of stone, founded on ledge, about 210 feet long, and supplies mills on both sides of the river, as follows:

On the right bank:

1. Globe cotton-mills; 18.5 feet fall; 200 horse-power (owning $\frac{51}{288}$ of total available power).

On the left bank:

2. George C. Ballou & Son's cotton-mill; 18.5 feet fall; 150 horse-power (owning $\frac{39}{288}$ of total).
3. Harris' mill No. 1; not running; 17 feet fall; 40 horse-power (owning $\frac{9}{288}$ of total.)
4. Mowry's grist-mill; 17 feet fall; 30 or 40 horse-power (owning $\frac{9}{288}$ of total).
5. Lyman cotton-mill; 17 feet fall; 70 horse-power (owning $\frac{18}{288}$ of total).
6. Bartlett cotton-mill; 17 feet fall; 70 horse-power (owning $\frac{18}{288}$ of total).
7. Lippitt woolen-mill; 15 feet fall; 150 horse-power (owning $\frac{36}{288}$ of total).
8. Harris' cotton-mill No. 5; 15 feet fall; 70 horse-power.
9. Harris' woolen-mills, Nos. 2, 3, and 4; 15 feet fall; 170 horse-power (Nos. 8 and 9 together owning $\frac{72}{288}$ of total).
10. American Worsted Company; 16 feet fall; 150 or 200 horse-power (owning $\frac{36}{288}$ of total).

Of these mills, Nos. 2, 3, 4, and 5 discharge their water direct to the river. No. 6 discharges into a race leading to No. 11, viz:

11. Pond's mill; 8½ feet fall; 25 horse-power, discharging the water into the river below the lower dam.

Nos. 7, 8, 9, and 10 discharge their water into a race or pond leading to Nos. 12 and 13, viz:

12. Groton cotton-mills; 14½ feet fall; 200 horse-power.
13. Clinton cotton-mill; 14½ feet fall; 300 horse-power.

Nos. 12 and 13 both discharge the water into the river below the lower dam.

The capacity of the stream in dry seasons is insufficient to run the mills above mentioned, and almost all have steam-power in reserve, in some cases enough to drive the entire machinery. During three months of the

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a The power given as owned by these mills does not correspond with the figures in the census returns. The proportions are correct, and the discrepancy in the number of horse-power is due to some inaccuracy in the returns, or to the fact that some of the mills do not use all the power to which they are entitled.

year steam is the chief dependence, and during six there is often a lack of water. In dry seasons there is no waste at any time of the day. The water is distributed to the different mills, according to the amounts owned, in the following manner: In the flumes leading from the canal to the mills were placed weirs, whose lengths were proportional to the amounts owned, the whole river being at first considered equivalent to a weir 96 feet long. These weirs are not all on the same level, but are lower at the lower end of the canal, to allow for the fall of the water surface, the intention being to have the water flow over all weirs at the same depth, at average stages of the water. In order to allow greater capacity at high water, all weirs were subsequently lengthened by one-half. The proportions of the entire power of the stream owned by the different mills are inclosed in parentheses in the list already given. Nos. 12 and 13 have half the river, and of this No. 12 owns two-fifths, and No. 13 three-fifths.

The lower dam at Woonsocket, which receives $\frac{126}{288}$ of the entire flow of the stream, supplies the cotton-mill of the Woonsocket Manufacturing Company, the fall being 15 or 16 feet.

Above Woonsocket the Blackstone is literally lined with mills. At Waterford a woolen-mill uses a fall of about 11 feet. At Blackstone the mills of the Blackstone Manufacturing Company use, in all—with a dam 15 feet high, a canal half a mile long, and a fall of 32 feet—a power of 1,000 horse-power during eight months. Above this, the total fall used on the main river below Worcester is about 200 feet, which, added to that below and including Blackstone, makes a total of nearly 400 feet; and as the elevation at Worcester is only 438 feet, it is evident that about all the fall is utilized. It would be hard, in fact, to find another stream in the country so completely utilized. A few unutilized falls are sometimes mentioned, but they are all small, and probably of no value. The reservoirs connected with the stream will be mentioned under the head of its tributaries.

THE TRIBUTARIES OF THE BLACKSTONE.

The first of these to be mentioned is Ten-Mile river, which empties into the Seekonk from the east, opposite the city of Providence, after draining an area of about 51 miles, principally in Massachusetts. Within a few miles of its mouth there are said to be three powers not used, the sites of the Cove mill, Hunt's mill, and the Central mill, with, in all, considerable fall. These mills were burned, and the powers have not since been used. The principal mills in operation on the stream are at Hebronville, where the fall is 9 feet, and the power 150 horse-power during part of the year, and scarcely any during three months; Dodgeville, where the fall is 12 feet, and Attleboro', where, at the Mechanics' mill, the fall is 9½ feet, with 80 horse-power during eight months. The stream is very small and unreliable, and the mills depend on steam, for, notwithstanding one reservoir used for regulating, the flow is almost nothing in summer. On the upper parts of the stream and its tributaries are some large falls but small powers.

Almost all of the small tributaries of the Blackstone below Woonsocket afford some small powers. Mill river, emptying just below the town, runs two large mills, but steam is depended upon. The most important tributary in Rhode Island is the Branch river, which has its sources in Burrillville and Gloucester, in Providence county, Rhode Island, and partly in Massachusetts, and flows in an easterly direction, draining a total area of about 100 square miles, and entering the Blackstone below the dam at Blackstone. Being fed by a number of ponds and reservoirs, it is an excellent stream for power, and is utilized to a considerable extent. The first mill as the stream is ascended is near the mouth, and is owned by the Blackstone Manufacturing Company. Between it and the mouth of the stream some fall which is not used is said to exist. At the cotton-mill of the Forestdale Manufacturing Company, just above, the fall is 16 feet, and 250 horse-power are used during about nine months, with steam for dry seasons. At Slatersville considerable power is used by John W. Slater's cotton-mills. There are three dams; from the upper one, 15 feet high, a race a mile long affords a fall of 18 feet at mill No. 2, which uses 220 horse-power all the year, and discharges the water to the lower level; the second, which is 21 feet high from the bed of the stream, serves as a reservoir dam, and only gets the waste over the upper one, the water being drawn from it into the pond below and then into the lower level, and conducted to mills Nos. 1 and 3, which use 20-feet fall and about 250 and 130 horse-power respectively. It is said that full capacity can generally be obtained nearly all the time, and that the upper dam could be raised, and an additional power thus obtained. Above this point there are four woolen-mills below the junction of the two headwaters of the river—Clear and Chepachet rivers. On the Chepachet river there are a number of mills, principally woolen, and the stream is fed by the following reservoirs: Keech pond, at the head, covering about 280 acres, with a range of about 8 feet, and Smith and Sayles' reservoir, covering 150 acres, with a range of 6 feet. These ponds are controlled by the mill-owners below. On Clear river and its branches there are likewise a number of woolen-mills, running quite constantly, on account of the reservoirs which feed the stream, of which there are the following: Pascoag reservoir, area about 550 acres, range about 16 feet, and Burlingame reservoir, about 100 acres, range 8 feet, both on the Pascoag river; Wallum pond, 800 acres, range 13 feet, and Wilson reservoir, 250 acres, range 11 feet, both on Clear river; and Herring pond, a natural pond covering 100 acres.

The Mumford river, which enters the Blackstone just below Uxbridge and drains an area of about 54 square miles, is fed by a number of reservoirs, and is well utilized. Its flow is very constant considering its size. At its mouth its capacity seems to be 150 horse-power during working hours, with a fall of 15 feet almost all the year. It is utilized within 4 miles of its mouth by six mills, with a total fall of 77 feet. Then comes a reservoir of 200

acres, averaging 4 feet deep, used only for regulating. Above this are numerous mills of various kinds, and several other reservoirs of sufficient capacity to increase the low-water flow very greatly. In fact, it is said no water is wasted during over six months of the year.

The upper tributaries of the Blackstone are in general excellent streams for power, their fall being rapid and their flow often regulated by reservoirs. Of these reservoirs the principal one is lake Quinsigamond, covering about 544 acres, and capable of being drawn down 6½ feet, its capacity being 154,000,000 cubic feet. It lies at an elevation above the sea of 358 feet, and its outlet falls 63 feet before it reaches the Blackstone, the distance being a little over 3 miles. The whole of this fall is utilized, there being at New England Village, near the outlet of the lake, a descent of 54 feet in a short distance, used on four falls. Above this point there are, besides Quinsigamond pond, two other reservoirs, the three aggregating an area of 956 acres. The power of the stream, though small, is therefore remarkably constant.

The other reservoirs on the tributary streams are too small to require special mention, covering, generally, less than 150 acres. As showing the large fall on some of the small tributaries, however, it may be mentioned that on Kettle brook, a stream not over 10 miles long, the total fall is about 360 feet, of which 306 are used. Other streams near the headwaters of the Blackstone are similar in character.

THE TAUNTON RIVER AND TRIBUTARIES.

The Taunton river, the most considerable stream of southeastern Massachusetts, is formed in Plymouth county, in the town of Bridgewater, by the junction of the Satucket and Matfield rivers, whence the stream pursues a general course toward the south and west, for a distance of about 24 miles in a straight line flowing by the city of Taunton and emptying into Mount Hope bay, near the Rhode Island line. It is navigable to the head of tide-water, at East Taunton, about 15 miles from the bay in a straight line, and above this point the area drained by the stream measures about 277 square miles, comprising a hilly and rolling country not well wooded. The stream has a small fall and a gradual declivity, with bed and banks of sand and gravel, and considerable areas of lowland along its course subject to overflow. Its flow is variable, yet much more constant than that of other streams of equal size along the coast, such as the Charles, Neponset, Ipswich, Exeter, etc. This is probably due to the lakes and ponds by which the flow is regulated, of which there are a number, though none of large capacity. There are only two powers on the stream, one at East Taunton, with a fall of 9 feet at low tide, and one near Bridgewater, with a fall of 8 feet. The former is utilized by the Old Colony Iron Company, and is at the head of navigation. The pond extends quite up to the upper power, there being no other fall on the stream. The power used was stated at 326 horse-power in 1880, and full capacity could be secured during from six to nine months, the power being very small during the rest of the time. The power near Bridgewater is used by a paper-mill, with about 100 horse-power during seven months, while during the rest of the year steam is depended upon. The drainage area above this place measures about 129 square miles. It is evident that the power of the Taunton river is not of much value, as to either amount or reliability. The tributaries are, in general, better sources of power, their fall being greater and their flow in some cases much more constant. The Satucket and Matfield rivers are utilized by small mills of various kinds, and the former has several artificial reservoirs. Town river, which joins the main stream at Bridgewater, runs the Bridgewater iron-works, but steam is depended upon. The Namasket river is the most constant stream in the drainage basin, being fed by a number of ponds, among which may be mentioned Assawompset (1,195 acres), Long (1,804 acres), Great Quittacus (1,110 acres), Little Quittacus (392 acres), and various others, aggregating nearly 7,000 acres in area. The stream flows from Assawompset pond in a northerly direction, and is only 5 or 6 miles long, emptying into the Taunton near the town of Middleboro', and draining a total area of about 63 square miles. Assawompset pond is not dammed, nor will the lowness of the country permit it to be; but its flow and level are controlled to some extent by flash-boards on the next dam below, so that its level varies to the extent of about 2½ feet. The other ponds are tributary to the Assawompset, and are not dammed. The stream is utilized by a box factory, with a fall of 10 feet, and a woolen-mill, with the same fall, and below the latter are two sites not in use, the upper known as the Muttock privilege, with a fall of 10 feet, formerly used by a grist-mill, the dam being still there, and the lower with a fall of about 6 feet. The woolen-mill uses 100 horse-power during about eight months, and at times not over 30 or 40.

Mill river, a small tributary running through Taunton, affords water-power to a number of mills during a few months of the year, but is reduced to almost nothing in summer, so that steam is relied upon. The same may be said of Three-Mile river, a tributary below Taunton.

THE POWER AT FALL RIVER, MASSACHUSETTS.

The power at Fall River, to which, perhaps, are principally due the growth and importance of the city as a manufacturing place, is remarkable in some respects. The water is derived from Watuppa pond, situated about 2 miles east of the city, with its high-water mark at an elevation above mean high tide of 129.01 feet, and covering

an area of about 5.39 square miles at high-water mark, and of 4.68 square miles at 5 feet below. The pond consists of the North and South ponds, connected by the "narrows", to which two other but smaller ponds, Sandy and Stafford's, are tributary. The total length of the lake is 7.67 miles, and its greatest width about 1.5 mile. Its drainage basin, including its own area, measures about 31.25 square miles, and comprises a hilly and rolling country, with a sandy, gravelly, and loamy soil, underlaid with granite rock. From this lake the Quequechan river, its outlet, flows westward through the city, falling rapidly over the ledges of solid rock on which the city is built, and reaching tide-water at Mount Hope bay after a course of 2 miles. The total fall of 129 feet is used by the following mills, in order:

Name of corporation.	Fall in feet as claimed by Watuppa Reservoir Company.	Number of horse power.
Troy Cotton and Woolen Manufacturing Company	15.48	150.6
Pocasset Manufacturing Company (cotton)	21.67 21.00	443.8
Watuppa Manufacturing Company (cotton)	15.38	160.0
Fall River Print-Works	10.00	104.0
Fall River Manufactory (cotton)	14.46	150.4
Annawan Manufactory (cotton)	14.73	153.2
Metacomet Mills (cotton)	16.00 +	148.2
Total	128.72±	1,310.2

The fall at the Metacomet mills varies with the tide, and is probably about 16 or 17 feet at high tide. The fall at the Troy mills varies with the level of the water in the river, from 15½ feet to less than 10 feet, averaging, it is said, about 13½ feet. It will be seen that the entire fall of the stream is utilized. The flow of water from the lake is controlled by a corporation known as the Watuppa Reservoir Company, representing all the mills below, and it is commonly stated that the amount of water used during working hours is 122.1 cubic feet per second, corresponding to 10.4 net horse-power per foot fall. On this basis, the power used by the various mills is as given in the third column of the above table. All of the mills, however, except the Annawan, have considerable steam-power in use all the time, the Annawan depending principally upon water-power, with steam only for dry seasons. The full capacity of 122 cubic feet per second cannot be obtained all the time, there being a deficiency during several months of the year, while at other times water runs to waste. When the lake is higher than 35 inches below high-water mark it is assumed that the flow is nearly constant, and as above stated, though in reality it varies; when the lake is below that point the flow is less, and when at the lowest point has been stated to vary in different years between 22 and 86 per cent. of the full discharge referred to, falling, therefore, as low as 26 or 27 cubic feet per second at times. In some years the full capacity is obtained all the time, but it would seem that not over 40 per cent. of that amount can be safely calculated upon as permanently available.

The drainage area of the lake being about 31 square miles, and the rainfall about 48 inches, then if 50 per cent. of the rainfall is collected, over, say, 30 square miles, the mean annual yield of the lake will be at the rate of about 53 cubic feet per second uniformly, or during the ten working hours about 127 cubic feet per second—a calculation showing that the yield to be expected would be somewhere near 122 cubic feet per second, as stated above. The level of the lake has been known to fall to 64 inches below high water; taking the range as 5 feet, and the mean area as 5 square miles, the storage capacity is found to be, in round numbers, about 700,000,000 cubic feet, or between five and six months' supply. The stream flows for the most part under the mills, being scarcely visible except in the mill-yards, and the dams are small affairs with no ponds of consequence.

It is to be mentioned that the water-supply of the city of Fall River, amounting to 150,000,000 gallons daily, is obtained from Watuppa pond, and that thereby the water-power of the outlet has been reduced by a small amount; to just what extent has been for some time under discussion.

Stafford's pond, covering an area of one-third of a square mile, lies at an elevation of 73.87 feet above high water of Watuppa lake, to which it is tributary, and drains an area of about 1.56 square miles, excluding its own surface.

THE MASSACHUSETTS STREAMS SOUTH OF THE CHARLES.

The streams coming under this head are of very little importance. From Fall River around to Plymouth county none are worth naming. In the latter county some possess the characteristics of sand-hill streams, and are fed by ponds sufficient to regulate their flow, but they are all small. Their beds are gravel and sand; they offer no abrupt falls, and are utilized principally by box factories. They often flow through meadow-lands and swamps, and their flow is comparatively constant. In Norfolk county there are a few larger streams, such as the Monataquot and the Neponset, but even they are of small importance, their flow being so variable, notwithstanding several artificial reservoirs by which they are fed, that the mills are obliged to depend upon steam for constant power.

THE CHARLES RIVER.

The Charles river takes its rise in the southern part of Massachusetts, near the corner of Norfolk, Worcester, and Middlesex counties. From this point its course, though very circuitous, is in general northeast, and the distance from source to mouth is about 25 miles in a straight line, though considerably farther by the river. Flowing partly in Norfolk and Middlesex counties, and partly between the two, the stream empties into the Atlantic at Boston, after passing the towns of Medway, Dedham, Newton, Waltham, Watertown, and others. The stream is tidal and navigable as far as the town of Watertown, about 6 miles from its mouth. About that point it drains an area of about 275 square miles, comprising an undulating country, with considerable low and flat ground and some swamps. No lakes of importance and no artificial reservoirs are connected with the river, so that its flow varies greatly, being reduced to almost nothing at some stages. Its fall is moderate as a whole, but in some places quite rapid, so that a number of powers are produced. The bed is generally gravel and mud, and the banks are often low. At one or two places, however, such as Newton Upper and Lower Falls, the bed is ledge, the banks are high, and the fall is precipitous. The freshets on the stream are not very severe, because the banks and meadow-lands are overflowed on the upper parts of the river, thereby restraining the floods. The stream is utilized for power to a considerable extent, there being no sites not occupied. The first power is at Watertown, where there are several mills, the fall being about 6 feet at low tide. The power is small when at its minimum, as the lowest flow affords only about 8 horse-power (gross) per foot continuously. Above Watertown we come to the Etna woolen-mills, with a small fall, then to mills at Waltham, and then to those at Newton Lower Falls. At this place there are three dams within half a mile or less, with, in all, 23 feet fall, and running a number of mills of various kinds. At Newton Upper Falls there are two dams, with a total fall of 23 feet, from which a paper-mill and a cotton-mill are run. Above this point the stream is very flat for a long distance, and almost connects with Mother brook, a tributary of the Neponset. A number of years ago one of the mill-owners on Mother brook dug a channel connecting the two streams, so that part of the water of the Charles has for years flowed into the Neponset. The case has come before the courts, and it has been decided that one-third of the water of the Charles is to go into the Neponset; and to regulate this amount, sills are made and placed at the same level across the Charles and across the channel to Mother brook, their lengths being as 2 to 1, so that the proper division of water is supposed to be effected. Above this point are several small powers, but none of consequence.

The water-power of the Charles will be seen to be of little value. On account of the variable flow of the stream, all the mills are obliged to depend upon steam-power in the summer, being generally provided with sufficient to run their entire machinery.

THE STREAMS BETWEEN THE CHARLES AND THE MERRIMACK.

The streams included under this head are of little importance as sources of power, being very variable in flow, and all small. The first north of the Charles is the Mystic, which, with its tributaries, is utilized to a considerable extent by small mills of various kinds. The next is the Saugus, a similar stream, draining an area of about 27 square miles, and also utilized. It is fed by several ponds, and is probably as good a stream as any in this section, its fall being considerable. To give an idea of its capacity, it may be mentioned that at Scott's woolen-mill, near the mouth, where the fall is 13 feet, five sets of machinery are run, by a breast-wheel, during about eight months of the year; but during the rest of the time the power is almost nothing, and steam-power is used. There is one unutilized privilege on the stream, with a fall of 8 feet.

The largest stream to be here mentioned is the Ipswich river, which drains an area of about 136 square miles above the head of tide-water, at Ipswich. The stream rises in Middlesex county, near the town of Wilmington, and flows in a general northeasterly direction, for a distance of 22 or 23 miles in a straight line, to tide-water, draining a rolling country, with no reservoirs, and only a few small ponds tributary to it. Its fall is small and its current generally sluggish. Its flow is very variable, being almost nothing in the summer, so that the stream is a poor one for power, resembling the Exeter and others in New Hampshire. At its mouth the Ipswich cotton-mills, with a fall of about 10 feet, use about 30 horse-power during seven months, but depend upon steam. There are some small mills above, but none of the powers are of consequence.

Table of drainage areas of the streams between the Mystic and the Merrimack.

Name of stream.	Above what point.	Drainage area.	Name of stream.	Above what point.	Drainage area.
		Sq. m.			*Sq. m.*
Mystic river	Mystic	20±	Three-Mile river	Mouth	76
Pawcatuck river	Westerly	286	Ten-Mile river	do	51
Do	Mouth of Wood river	111	Do	Dodgeville	23
Wood river	Mouth	83	Quequechan river	Outlet of lake Watuppa	*a* 27
Pawtuxet river	do	229	Taunton river	Lower Taunton	337
North branch of the Pawtuxet river	Junction with South branch	108	Do	East Taunton	277
South branch of the Pawtuxet river	Junction with North branch	71	Do	Paper-mill	129
North branch of the Pawtuxet river	Hope	98	Mill river	Mouth	44
Woonasquatucket river	Olneyville	48	Assawompset river	do	63
Do	Mouth	72	Winetuxet river	do	35
Blackstone river	Pawtucket	458	Satucket river	do	32
Do	Lonsdale	438	Matfield river	do	30
Do	Manville	413	Nippenicket river	do	56
Do	Woonsocket	350	Neponset river	Milton Lower Mills	101
Do	Blackstone	248	Charles river	Brookline	281
Branch river	Mouth	100	Do	Newton Lower Falls	218
Do	Slatersville	95	Saugus river	Mouth	27
Munford river	Mouth	54	Ipswich river	Ipswich	136
Quinsigamond river	do	35			

a By measurements of the writer.

Table of power utilized on the coast streams south of the Merrimack.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Long Island sound	Connecticut	New London	Flour and grist	5	64	79
Do	do	do	do	Saw	4		75
Do	do	do	do	Plaster	1		15
Do	do	do	do	Paper	2	50	180
Pawcatuck river	do	do	do	Sash, door, and blind	1	3	10
Do	do	do	do	Machinery and woolen	1	5	100
Tributaries of	Pawcatuck river	do	do	Woolen	2	37	55
Do	do	do	do	Carriage and wagon	1	12	18
Pawcatuck river and tributaries	Long Island sound	Rhode Island	Washington	Woolen	12	96+	590+
Do	do	do	do	Cotton	18	323	1,479
Do	do	do	do	Agricultural implements	1	10	6
Do	do	do	do	Carriage and wagon	1		2
Do	do	do	do	Twine	2	15	22
Do	do	do	do	Machinery	2	24	55
Do	do	do	do	Sash, door, and blind	1	22	4
Do	do	do	do	Shoddy	2	24	40
Do	do	do	do	Wheelwrighting	2		7
Do	do	do	do	Flour and grist	7	123	124
Do	do	do	do	Saw	13	155+	189
Do	do	do	Kent	do	7	113	257
Do	do	do	do	Flour and grist	1	11	28
Pawtuxet river	do	do	do	Cotton	2	25	1,100
South branch of the Pawtuxet river	Pawtuxet river	do	do	do	8	142	2,480
Do	do	do	do	Woolen	1	16	60
Do	do	do	do	Flour and grist	2	23	73
North branch of the Pawtuxet river	do	do	do	Cotton	4	97	1,000
Do	do	do	Providence	do	2	29	90
Do	do	do	do	Drugs and chemicals	1	27	30
Other tributaries of the	do	do	Kent	Saw	1	8	4
Do	do	do	do	Flour and grist	6	87	128
Do	do	do	do	Machinery	1	7	40
Do	do	do	do	Blacksmithing	1	16	12
Do	do	do	do	Woolen	4	118	155
Do	do	do	do	Cotton	6	183	325
Do	do	do	Providence	do	7	188+	770
Do	do	do	do	Wheelwrighting	1	8	8

Table of power utilized on the coast streams south of the Merrimack—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of the	Pawtuxet river	Rhode Island	Providence	Shoe-laces	1	14	110
Do	do	do	do	Saw	3	46	49
Woonasquatucket river	Providence river	do	do	Flour and grist	1	14	95
Do	do	do	do	Woolen	2	39	215
Do	do	do	do	Cotton	9	151	1,064
Tributaries of	Woonasquatucket river	do	do	do	1	16	10
Do	do	do	do	Machinery	1	35	8
Do	do	do	do	Dyewoods, etc	1	8	60
Blackstone river	Providence river	do	do	Flour and grist	3	43	230
Do	do	do	do	Woolen	5	72	737
Do	do	do	do	Cotton	21	271	6,415
Do	do	do	do	Paper	1	18	100
Do	do	do	do	Worsted	1	16	200
Do	do	Massachusetts	Worcester	Woolen	6	60	670
Do	do	do	do	Rolling	1	16	150
Do	do	do	do	Cotton	9	130	2,240
Do	do	do	do	Blacksmithing	1	6	8
Do	do	do	do	Flour and grist	3	30	125
Do	do	do	do	Sash, door, and blind	1	.8	50
Do	do	do	do	Felt	1	15	180
Tributaries of the	Blackstone river	Rhode Island	Providence	Woolen	12	201	1,190
Do	do	do	do	Worsted	2	56	115
Do	do	do	do	Cotton	13	220+	1,600
Do	do	do	do	Wood-turning	1	6	20
Do	do	do	do	Wire-works	1	....	10
Do	do	do	do	Agricultural implements	1	14	30
Do	do	do	do	Blacksmithing	1	8	2
Do	do	do	do	Bread and crackers	1	....	2
Do	do	do	do	Carpentering	1	14	16
Do	do	do	do	Flour and grist	5	95	95
Do	do	do	do	Saw	11	194	315
Do	do	do	do	Machinery	2	26	50
Do	do	do	do	Shoddy	1	18	20
Do	do	Massachusetts	Worcester	Hosiery	1	....	60
Do	do	do	do	Worsted	2	18	104
Do	do	do	do	Cotton	9	229	1,513
Do	do	do	do	Woolen	20	350	1,192
Do	do	do	do	Wire	1	17	20
Do	do	do	do	Tools	2	44	179
Do	do	do	do	Shoddy	8	182	348
Do	do	do	do	Sash, door, and blind	1	8	20
Do	do	do	do	Machinery	6	80+	295
Do	do	do	do	Saw	10	134	177
Do	do	do	do	Leather	1	7	16
Do	do	do	do	Wooden handles	2	22	33
Do	do	do	do	Flour and grist	12	165	290
Do	do	do	do	Boxes	2	....	35
Do	do	do	do	Cutlery	2	61	411
Do	do	do	do	Blueing	1	....	30
Do	do	do	Bristol	Flour and grist	1	7	20
Do	do	do	do	Foundery	1	8	50
Do	do	do	do	Jewelry	1	8	30
Do	do	do	do	Wood-turning	1	6	15
Do	do	do	do	Machinery	1	15	35
Do	do	do	do	Worsted	1	32	97
Do	do	do	do	Cotton	4	51	371
Do	do	do	Norfolk	Woolen	1	23	40
Do	do	do	do	Jewelry	3	20+	43
Other streams	Atlantic ocean	Rhode Island	Washington	Woolen	5	58	264
Do	do	do	do	Cotton	5	70+	200
Do	do	do	do	Flour and grist	7	98	116
Do	do	do	do	Saw	1	13	13
Do	do	do	do	Locksmithing	1	....	3
Do	do	do	do	Printing	2	....	4
Do	do	do	Newport	Flour and grist	2	18	44
Taunton river and tributaries	Narragansett bay	Massachusetts	Bristol	Rolling	1	10	326

Table of power utilized on the coast streams south of the Merrimack—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Taunton river and tributaries	Narragansett bay	Massachusetts	Bristol	Cotton	6	51	860
Do	do	do	do	Agricultural implements	1	80	175
Do	do	do	do	Boxes	1	13	50
Do	do	do	do	Boots and shoes	1	13	10
Do	do	do	do	Brass and copper rolling	2	43	800
Do	do	do	do	Coffins	1	12	28
Do	do	do	do	Comb	1	14	20
Do	do	do	do	Cotton-waste	1	8	20
Do	do	do	do	Tools	2	13	10
Do	do	do	do	Cutlery	2	21	40
Do	do	do	do	Plated ware	1	7	120
Do	do	do	do	Drugs	1	12	10
Do	do	do	do	Flour and grist	4	62	113
Do	do	do	do	Nail	2	19	80
Do	do	do	do	Paper	1	[illegible]	64
Do	do	do	do	Jewelry	1	12	20
Do	do	do	do	Toys	1	6	12
Do	do	do	do	Saw	20	210	571
Do	do	do	do	Machinery	1	11	23
Do	do	do	Plymouth	Cotton	1	14	52
Do	do	do	do	Woolen	1	10	107
Do	do	do	do	Forges	1	6	20
Do	do	do	do	Rolling	2	34	170
Do	do	do	do	Boots and shoes	2	11	27
Do	do	do	do	Boxes	10	121	214
Do	do	do	do	Flour and grist	5	55	91
Do	do	do	do	Nail	3	37	66
Do	do	do	do	Saw	15	163	277
Do	do	do	do	Machinery	4	42	66
Do	do	do	do	Paper	1	8	100
Do	do	do	Norfolk	Glue	1	13	25
Do	do	do	do	Hosiery	1	20	30
Neponset river and tributaries	Atlantic ocean	do	do	Brass and copper rolling	1	19	225
Do	do	do	do	Chocolate	1	[illegible]	60
Do	do	do	do	Emery	1	13	25
Do	do	do	do	Ink	1	6	35
Do	do	do	do	Flour and grist	3	32	140
Do	do	do	do	Machinery	2	36	55
Do	do	do	do	Rolling	1	12	167
Do	do	do	do	Leather-board	2	30	55
Do	do	do	do	Tannery	1	12	27
Do	do	do	do	Saw	3	36	70
Do	do	do	do	Paper	3	42	510
Do	do	do	do	Screws	1	11	8
Do	do	do	do	Hosiery	1	12	10
Do	do	do	do	Sporting goods	1	6	10
Do	do	do	do	Tools	1	10	6
Do	do	do	do	Cotton	8	126	407
Do	do	do	do	Woolen	4	54	315
Do	do	do	do	Silk	1	13	30
Do	do	do	Suffolk	Chocolate	1	7	175
Charles river and tributaries	do	da	Norfolk	Hosiery	1	[illegible]	45
Do	do	do	do	Felt	3	42	300
Do	do	do	do	Woolen	3	24	220
Do	do	do	do	Boxes	1	[illegible]	10
Do	do	do	do	Cooperage	1	16	12
Do	do	do	do	Twine	1	9	100
Do	do	do	do	Flour and grist	1	9	10
Do	do	do	do	Machinery	1	10	10
Do	do	do	do	Saw	7	59	175
Do	do	do	do	Paints	1	12	40
Do	do	do	do	Paper	5	52	313
Do	do	do	do	Shoddy	4	63	275
Do	do	do	Worcester	Flour and grist	1	21	56
Do	do	do	Middlesex	Wheelwrighting	1	9	10
Do	do	do	do	Woolen	1	4½	125

Table of power utilized on the coast streams south of the Merrimack—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Charles river and tributaries	Atlantic ocean	Massachusetts	Middlesex	Hardware	1	22	6
Do	do	do	do	Shoddy	1	9	40
Do	do	do	do	Cotton	2	26	820
Do	do	do	do	Furniture	1	27	10
Do	do	do	do	Steam-fitting apparatus	1	6	25
Do	do	do	do	Carpentering	1	......	30
Do	do	do	do	Flour and grist	6	61	198
Do	do	do	do	Nails	1	......	45
Do	do	do	do	Saw	1	12	20
Do	do	do	do	Saws	1	......	15
Do	do	do	do	Machinery	1	18	6
Do	do	do	do	Watch and clock materials	1	......	1
Do	do	do	do	Leather-board	1	8	100
Do	do	do	do	Paper	4	48	314
Do	do	do	do	Sash, door, and blind	1	5	8
Do	do	do	do	Sewing-machines	1	14	23
Ipswich river and tributaries	do	do	do	Saw	1	7	10
Do	do	do	Essex	Flour and grist	3	29	115
Do	do	do	do	Saw	6	76	141
Do	do	do	do	Paper	1	10	100
Do	do	do	do	Woolen	1	8	65
Do	do	do	do	Hosiery	1	7	40
Do	do	do	do	Matches	1	12	50
Do	do	do	Middlesex	Flour and grist	1	8	25
Other streams	do	do	Bristol	Cotton	7	100	1,785
Do	do	do	do	Boxes	1	12	15
Do	do	do	do	Flour and grist	10	118	284
Do	do	do	do	Saw	14	143	372
Do	do	do	do	Wheelwrighting	1	7	8
Do	do	do	Barnstable	Cutlery	1	8	15
Do	do	do	do	Foundery	2	35	55
Do	do	do	do	Shoddy	1	10	67
Do	do	do	do	Tar and turpentine	1	8	15
Do	do	do	do	Wheelwrighting	1	7	7
Do	do	do	do	Flour and grist	2	19	33
Do	do	do	do	Woolen	1	11	27
Do	do	do	Plymouth	Rolling	3	56	625
Do	do	do	do	Cotton	3	53	120
Do	do	do	do	Boxes	5	45	73
Do	do	do	do	Carriage and wagon materials	1	10	15
Do	do	do	do	Twine	1	18	20
Do	do	do	do	Cutlery	2	33	52
Do	do	do	do	Flour and grist	11	95	225
Do	do	do	do	Bolts, nuts, etc	2	28	60
Do	do	do	do	Forgings	2	......	70
Do	do	do	do	Foundery	2	14	12
Do	do	do	do	Nails	8	108	143
Do	do	do	do	Saw	64	641	1,623
Do	do	do	do	Musical instruments	1	8	9
Do	do	do	do	Rubber goods	1	12	80
Do	do	do	do	Wheelwrighting	1	8	5
Do	do	do	do	Zinc	2	22	75
Do	do	do	Suffolk	Flour and grist	2	15	90
Do	do	do	Norfolk	Woolen	2	17	125
Do	do	do	do	Rolling	1	6	294
Do	do	do	do	Boxes	2	16+	110
Do	do	do	do	Boot and shoe findings	1	12	12
Do	do	do	do	Flour and grist	1	11	40
Do	do	do	do	Nails	1	10	16
Do	do	do	do	Isinglass	1	18	60
Do	do	do	do	Lasts	1	11	15
Do	do	do	do	Saw	2	25	62
Do	do	do	do	Paper	1	13	62
Do	do	do	Middlesex	Fur-dressing	1	14	35
Do	do	do	do	Jewelry	1	......	3
Do	do	do	do	Tannery	1	12	25

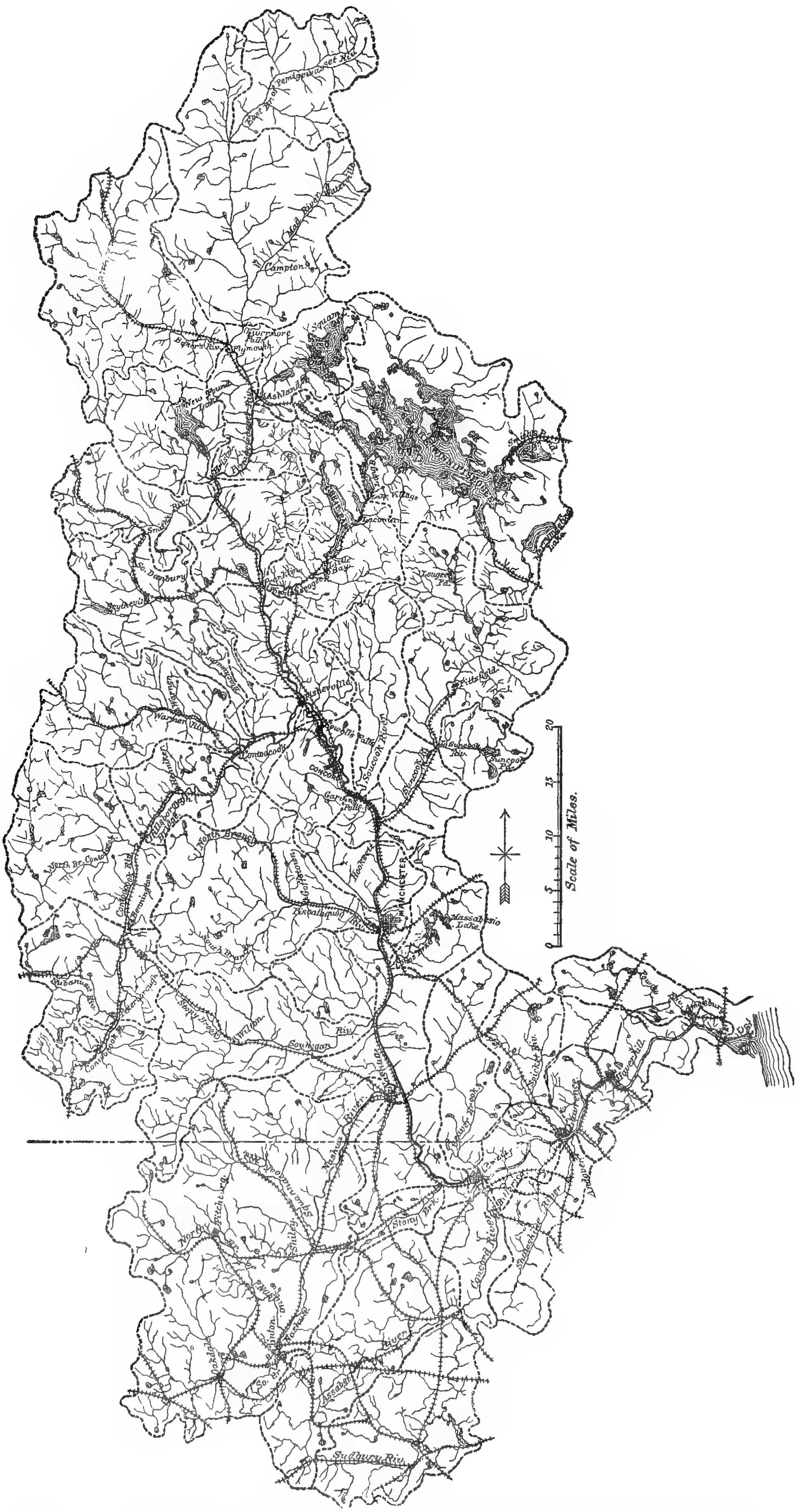

Fig. 3. MAP OF THE DRAINAGE BASIN OF THE MERRIMACK RIVER.

Table of power utilized on the coast streams south of the Merrimack—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other streams	Atlantic ocean	Massachusetts	Middlesex	Saw	4	28+	145
Do	do	do	do	Machinery	1	6	5
Do	do	do	do	Musical instruments	3		65
Do	do	do	do	Printing and publishing	2		2
Do	do	do	do	Cutlery and edge-tools	1		16
Do	do	do	do	Wheelwrighting	1		2
Do	do	do	do	Watch and clock materials	1	9	2
Do	do	do	Essex	Woolen	2	30	95
Do	do	do	do	Carriage materials	1	27	55
Do	do	do	do	Flour and grist	12	111	752+
Do	do	do	do	Furniture	1	7	10
Do	do	do	do	Saw	3	40	44
Do	do	do	do	Paint	1	5	40
Do	do	do	do	Tobacco	4	78	110
Do	do	do	do	Upholstering materials	1	18	25
Do	do	do	do	Vinegar	1	26	25
Do	do	do	do	Blacksmithing	1	12	25

III.—THE MERRIMACK RIVER AND TRIBUTARIES.

THE MERRIMACK RIVER.

The Merrimack river, the most noted water-power stream of the world, and on which, with its tributaries, there is probably more power utilized than in any other drainage basin of equal size in America, merits a particular description and a careful study. The sources of the stream lie in Grafton, Carroll, and Belknap counties, New Hampshire, but the main stream is formed at the town of Franklin, on the line of Belknap and Merrimack counties, by the junction of the Pemigewasset and the Winnipiseogee rivers, the former of which takes its rise in the heart of the White mountains, while the latter has its source in the lake of the same name, the largest single sheet of water in the state. These two headwaters will be discussed in detail further on. From their junction the main stream pursues a course a few degrees east of south, passing through Merrimack and Hillsborough counties, and then into Middlesex county, Massachusetts, where it bends abruptly toward the east, and flows in a direction north of east through Essex county to the sea. The total length of the stream, from its origin, at Franklin, to its mouth, at Newburyport, is in the neighborhood of 110 miles, and the total area drained is about 4,916 square miles, of which about 3,780 square miles lie in New Hampshire and about 1,136 square miles in Massachusetts. The table on page 56 gives the drainage areas of the principal tributaries, and of the main stream, above various points. The drainage basin is well populated, and the course of the stream lies by the important and populous cities of Concord and Manchester, New Hampshire, and Lowell, Lawrence, Haverhill, and Newburyport, Massachusetts. The head of tide, and of navigation for coasting vessels, is a few miles above Haverhill, but small river boats can ascend as far as Lawrence. Above that point there is no navigation on the river, although there are long stretches of still water behind the various dams supplying water-power; and although the idea of rendering the stream navigable even to Manchester has been broached, the cost of the undertaking has prevented any steps being taken to carry it out.

The physical character of the area drained by the stream varies greatly. In the upper part it is mountainous, rugged, and rocky, the streams flowing down from the steep slopes, and winding along through the intervale or alluvial lands to the lower or hill country, where the slopes are more gradual and the country only gently rolling. Toward the lower part of the stream the country becomes quite flat, and some of the tributaries, like the Concord river, drain considerable areas of low swampy country.

The comparatively small extent of the lower or eastern division, and the presence of the first fall at the head of tide-water, are facts which have received notice in the introduction. The drainage basin has been deprived of its forests to a considerable extent, and, except in the uppermost portions, scarcely any part of the basin can be called thickly wooded. The flow of the stream has in consequence no doubt diminished in constancy. As regards natural reservoirs, however, the Merrimack is favored to an unusual degree, there being, on the upper waters, about 100 square miles of reservoir area now under control, and managed by manufacturing and water-power corporations

lower down on the stream. On page 29 will be found a full list of these reservoirs, and subsequent pages give other information regarding them. Their importance in adding to the low-water flow of the river can hardly be overestimated, and although there are other streams possessing equal or greater advantages as regards storage, there are probably none in which those advantages have been so extensively and systematically improved.

The bed and banks of the Merrimack are in every way favorable for the development of power. The stream flows generally over ledges of rock at the places where power is available or utilized, while the banks are, as a rule, at those places high and firm. In places there are quite extensive tracts of bottom-land subject to overflow, but they generally occur in localities where no power is available. Between the ledges and rapids the bed of the stream is composed of gravel, sand, and bowlders, and the fall is sometimes very small. The declivity of the stream is shown approximately by the following table:

Declivity of the Merrimack river.

Place.	Distance from mouth.	Elevation above mean tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0			
Mitchell's falls	21.5	0	21.5	0	0
Foot of locks at Lawrence	26.5	10	5	10	2
Top of Lawrence dam	27.5	39			
Top of flash-boards	27.5	42	1	32	32
Foot of Hunt's falls	36.5	42	9	0+	0.0+
Head of Hunt's falls	37.5	53	1	11	11
Top of Pawtucket dam, Lowell	39.5	87			
Top of flash-boards	39.5	89	2	36	18
State line	48.7	90			
Mouth of Nashua river	53.0	93			
Foot of Cromwell's falls	57.2	93	17.7	4	0.23
Foot of Goff's falls	64.0	112	6.8	19	1.7
Head of Goff's falls	64.6	117	0.6	5	8.3
Manchester, below falls	68.0	126	3.4	9	2.7
Top of Manchester dam	69.0	178			
Top of flash-boards	69.0	180	1	54	54
Hooksett, below falls	77.7	181	8.7	1	0.11
Hooksett, top of dam	77.8	197	0.1	16	160
Foot of Garvin's falls	82.5	199	4.7	2	0.43
Head of Garvin's falls	82.7	227	0.23	28	123
Foot of Sewell's falls	93 ±	229	10.3	2	0.2
Head of Sewell's falls	95 ±	248	1.75	19	10.86
Mouth of Contoocook	96.2	249	1.2	1	0.8
Franklin, head of river	110.1	269	13.8	20	1.4

The average fall of the stream is 2.45 feet per mile. Though this is not a large fall, the greater part of it occurs in short distances, at six places, giving rise to the noted and remarkable powers for which the river is renowned. The map prefixed to this report shows the general shape of the basin and the course of the river, and the profile (Fig. 4) shows graphically the declivity of the stream.

The flow of the stream, naturally not very variable, is rendered comparatively constant by the control exercised over the large reservoirs in New Hampshire. Daily gaugings of the stream are being made at Lawrence, Massachusetts, and when sufficient data shall have been accumulated the records which have been kept by the water-power company there during the past thirty-five years will enable one to form an accurate estimate of the flow at any time during that period. Nothing has yet been given to the public, however, and the tables on pages 9 and 10 give all the data regarding flow that can now be presented. The freshets on the stream are not by any means violent, as compared with those on western and southern rivers. At the lower locks in Lawrence, where continuous records of the height of the water have been kept for over thirty-five years, the extreme range is 26½ feet. The ordinary yearly range is from 10 to 15 feet, and there are generally several freshets every year in which the water rises to 10 or 12 feet above low water. The stream is generally lowest in the summer, though sometimes nearly as low during the winter. The freshets are irregular in their occurrence, but generally take place in the spring with the greatest violence.

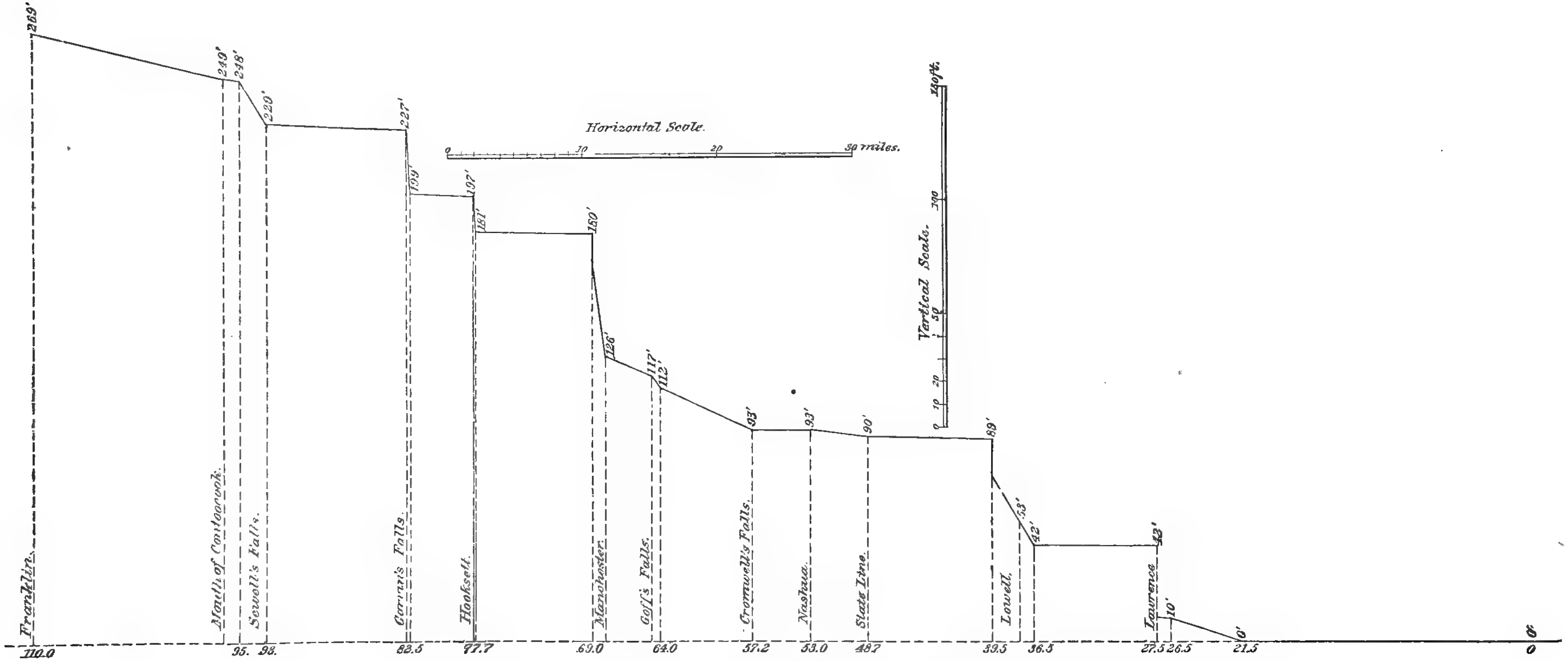

Fig. 4. PROFILE OF THE MERRIMACK RIVER.

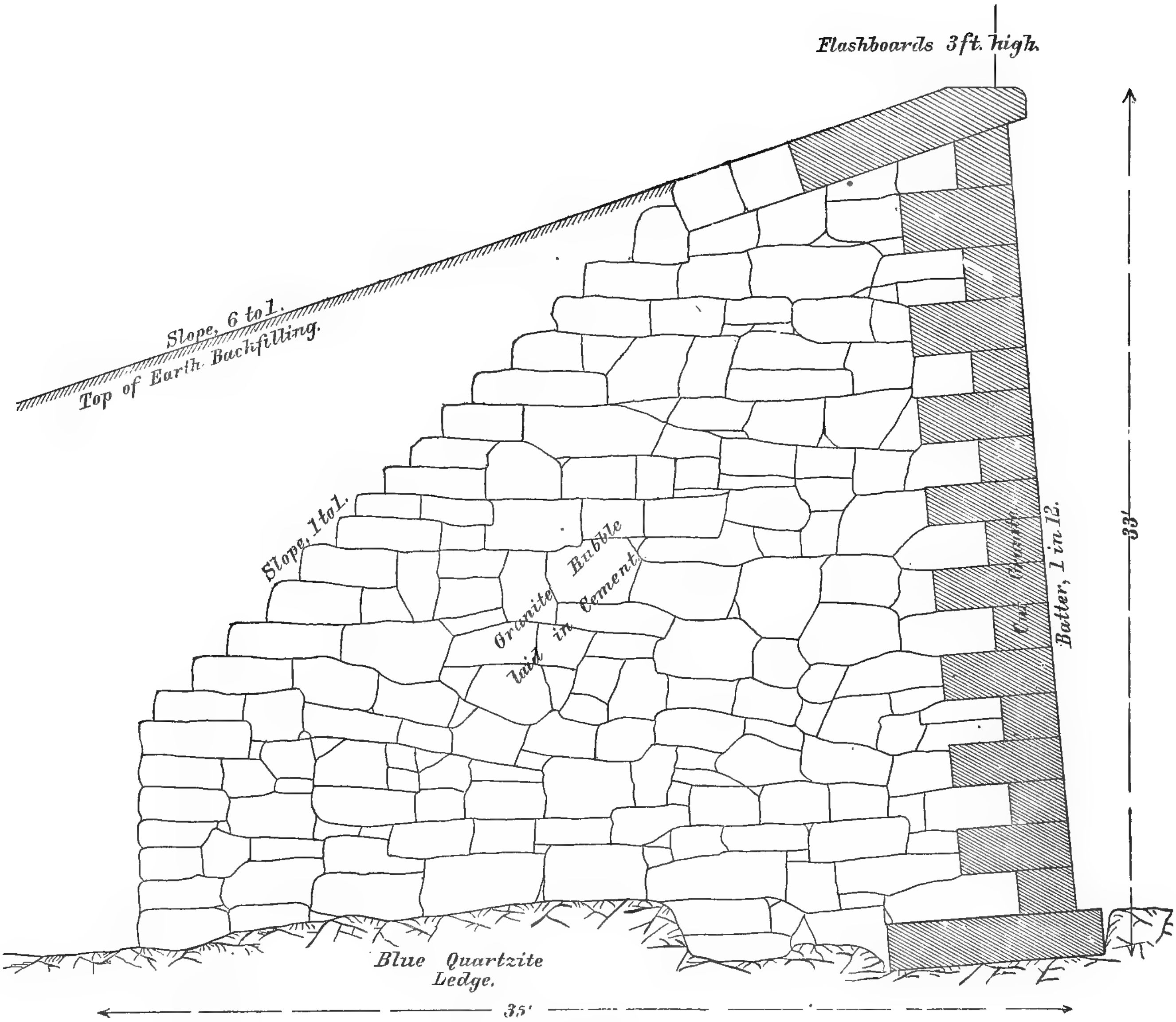

Fig. 5. SECTION OF DAM AT LAWRENCE, MASS.

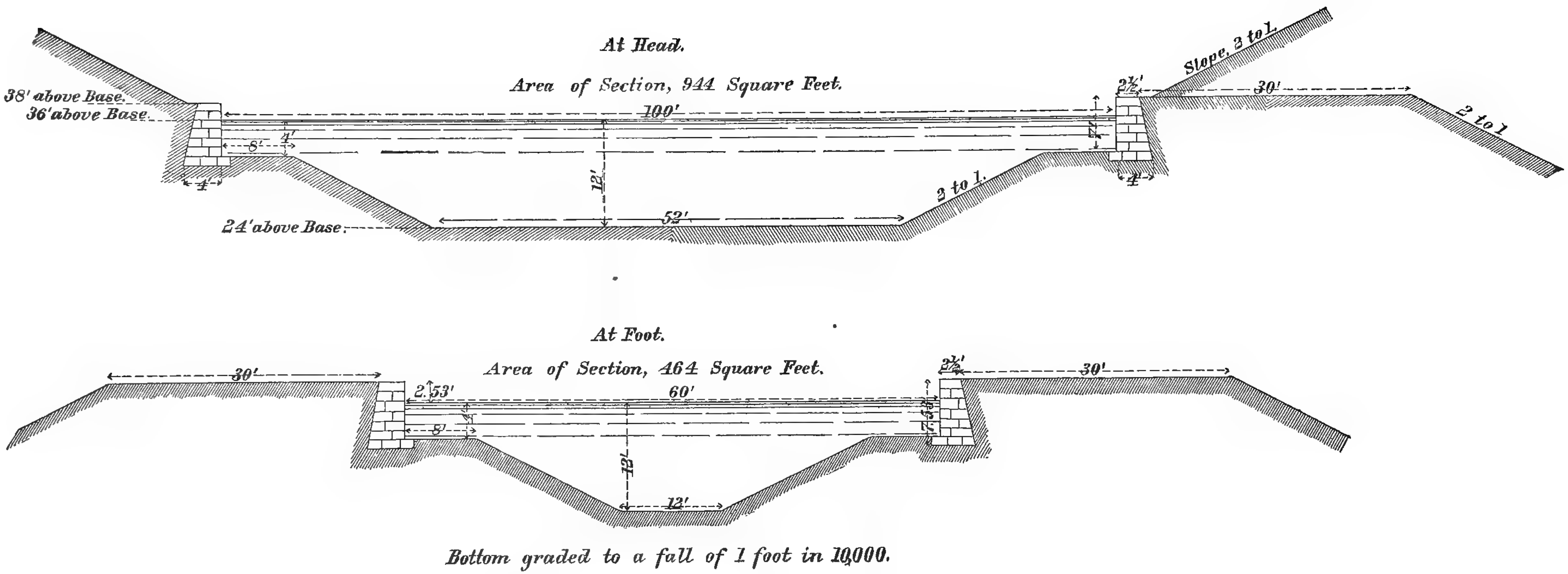

Fig. 6. SECTIONS OF NORTH CANAL AT LAWRENCE, MASS.

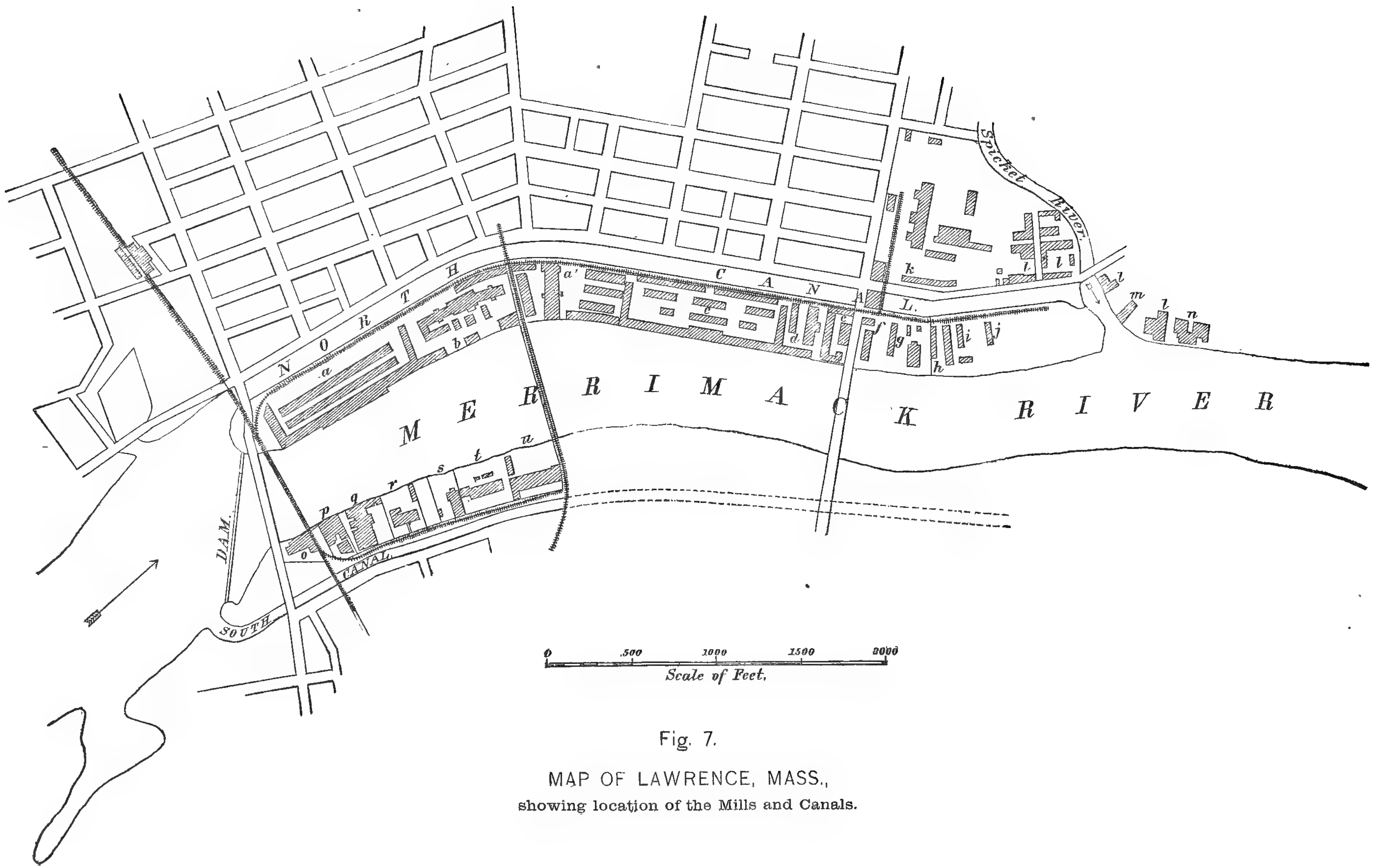

Fig. 7.

MAP OF LAWRENCE, MASS.,
showing location of the Mills and Canals.

The mean annual rainfall over the basin of the Merrimack is, according to the Smithsonian charts, about 43 inches, of which 10 fall in spring, 11 in summer, 13 in autumn, and 9 in winter. This distribution is evidently very favorable for a constant flow.

As regards accessibility, it is sufficient to refer to the map, which shows that the stream is followed closely by a railroad for its entire length. No river can be more favorably situated in this respect.

We proceed to describe the water-powers in their order as the stream is ascended:

From the mouth of the river to Haverhill bridge, a distance of 17½ miles, there is a navigable depth of 12 feet at ordinary high water. Thence to the head of Mitchell's falls, a distance of 4 miles, there is a depth of 4½ feet in ordinary stages of the river, with the mill-water at Lawrence running. Above these falls the effect of the tide is not noticeable. Mitchell's falls are of no value for water-power, the fall varying with the tide, and only amounting to 6 or 8 feet even at low water.

The first water-power on the river, and one of the most important and carefully managed in the United States, is that at Lawrence, Massachusetts.

THE WATER-POWER AT LAWRENCE, MASSACHUSETTS.

The development of the water-power at this place dates from the year 1845, when the owners of the land and the water-power were incorporated as the Essex Company, with a capital of $1,000,000. Steps were at once taken toward the utilization of the power, and on July 5, 1845, the contract was concluded for the building of the substantial dam which still holds back the waters of the river and diverts them into the channels of industry. The structure is built in a curve, the chord being 900 feet, and the center ordinate 14.97 feet. Its maximum height is 40½ feet, and its average height about 32 feet, the breadth at the base being about 35 feet. The front face has a batter of 1 in 12, the top or capping is level for 3 feet from the face, then slopes back or up-stream 1 foot in 3 feet, for 12 feet beyond which the back is stepped off at a slope of 45 degrees. Its section is shown in Fig. 5. It is composed entirely of solid stone masonry, resting on a rock foundation, which is stepped off to receive it, the front of the dam being secured by blasting out a trench in the rock, along the entire length, in which the first course of granite masonry is laid, all the stones being headers, and the next course above being all stretchers, doweled to the foundation course. The face of the dam is all of dressed stone, the headers and stretchers of each course being dovetailed together, and the capping stones being doweled to each other and to the next facing course below. The remainder of the dam is of rough stone, laid in cement, with a back-filling of earth, sloping 6 to 1. The level of the water may be raised 3 feet above the crest of the dam, by means of flash-boards, in lengths of 16 feet, resting against 1¼-inch iron bolts inserted at intervals of 20 inches in holes drilled in the capping stones. The top of the dam is at 34.12 feet on the company's scale. At the south end of the dam is a substantial wooden fishway. The excavation for the dam was begun August 1, 1845, the first stone laid September 19 of the same year, and the structure completed in 1848, its construction having occupied almost exactly three years. The rock excavation in preparing the foundation amounted to 1,700 cubic yards; the quantity of masonry laid in cement was 29,000 cubic yards, and the surface of hammered granite was 148,000 square feet. The cost of the dam, including coffer-dam and all incidentals, was $250,000. The agent and engineer of the Essex Company was Charles S. Storrow, who designed the dam and canals and the general development of the water-power, and he was efficiently assisted in carrying out the work after April, 1846, till its completion, by Captain Charles H. Bigelow, as engineer in charge of construction.

The dam crosses the stream in an oblique direction, and on each side there are extensive wing-walls, that on the south side being 324 feet long, and that on the north side 405 feet, making, with the overfall, a total length of 1,629 feet. There is a canal on each side of the river. That on the north side, which is the principal one, is 5,330 feet long, 100 feet wide at the upper end, and 60 at the lower end. Its section is shown in Fig. 6. Its depth is 12 feet in the middle and 4 feet at the side walls, and the bottom is graded to a fall of 1 foot in 10,000, or 0.53 foot in the length of the canal. The head-gates are 24 in number, arranged in six sets of 4 each, or closing six sluice-ways between piers, 12 feet deep and 9 feet wide, so that each gate is 3 feet high and 9 feet long. They are operated by hand. At the head of the canal there is also a lock; and at the foot there are three locks, descending into the river, together with a waste-way by which the canal may be emptied into the Spicket river, which joins the Merrimack just at the foot of the canal. Between the canal and the river are situated the principal mills, as the map (Fig. 7) shows; and at a distance of about 80 feet from the canal a line of sheet-piling extends parallel to it for nearly half its length, to prevent percolation, the bank being to a considerable extent artificial. The cost of this canal, with the structures connected with it, was about $250,000, and the excavation amounted to 266,000 cubic yards.

The south canal was built in 1866, and carried for a distance of 2,000 feet, with a rectangular section 60 feet wide and 10 feet deep. It is expected to continue it some 1,500 feet farther, beyond which an iron penstock will be laid. The head-gates are 16 in number, in four sets, and are operated by hand. This canal has cost about $150,000.

The Essex Company's dam crosses the river near the foot of what were known as Bodwell's falls, over which it backs the water, deadening the current for a distance of 9 miles, to the foot of Hunt's falls, with an average width of perhaps 600 feet, giving a pond area of about 29,000,000 square feet, or not far from a square mile. This area, in connection with the large ponds on the stream, above, is sufficient to prevent any waste of water in a dry

season; and it sometimes occurs that there is scarcely any waste of water over the dam for weeks at a time, though at such times, even, the mills are using considerable surplus water (see page 27). The water has been drawn nearly 2 feet below the top of the flash-boards in very dry seasons, owing to the large quantity of water used at night, when none is allowed to pass the Lowell dam.

The fall at the mill-wheels in Lawrence is, during ten months of the year, from 26 to 30 feet. During the spring and autumn freshets it is often reduced to 20 feet for a few days, and on one occasion, in April, 1852, it was reduced to 7 feet for a few hours. This was the greatest freshet known in one hundred years. There is a difference in fall of only 0.3 or 0.4 feet between the head and the foot of the canal. The table on page 27 gives the mills using power.

The Essex Company sells power at Lawrence by the "mill-power", which is defined as follows:

Each mill-power is declared to be the right to draw from the nearest canal or water-course of the grantors, and through the land to be granted, so much water as shall give a power of 30 cubic feet of water per second, when the head and fall is 25 feet; and no more is to be drawn in any one second, nor is the same to be drawn more than 16 hours in each day of twenty-four hours—and in order to prevent disputes as to the power of each mill-privilege in the variations of the height of water from changes in the season or other causes, it is understood and declared that the quantity of water shall be varied in proportion to the variation of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them: thus on a head and fall of 30 feet the quantity of water to be used would be $24\frac{24}{29}$ cubic feet per second; and the respective parties, where either has any lawful interest therein, may at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the raceway thereof to measure and compare the quantity of water used with the quantity granted, and in the measurement all wastage shall be included.

To express in other words the method of determining the quantity of water, instead of dividing 750 (the product of 25 and 30) by the fall, 720 is divided by the fall minus one foot. Tables are used in the office, giving quantity of water per mill-power corresponding to fall. The Essex Company is to maintain the same and principal canals; the raceways and flumes of the mills are property of the grantees. I quote further from the "proposals", as follows:

In order to continue in the grantors an interest in common with the grantees for the preservation and support of the mill-powers which may be granted, and to secure a fund to indemnify the grantees for expenses which may be incurred by them for making repairs, if the grantors should improperly neglect to make them, it is proposed that part of the consideration of every sale, and all that is to be allowed the grantors for the repairs, etc., by them assumed, should be paid or secured to them in the form of a reservation of rent. *It is therefore declared* that each mill-power with the land to which it is annexed shall forever be subject to a perpetual annual rent of at least two hundred and sixty ounces, troy weight, of silver of the present standard fineness of the silver coin of the United States, (*a*) or an equivalent in gold, at the option of the grantee at the time of payment.

The following additional quotations from the "proposals" need no elucidation:

If any grantee shall sustain any injury from deficiency of water happening from any cause whatever, other than his own neglect or misconduct, his rent may cease during the time such deficiency may continue, but no longer. Provided, that where more than one mill-power shall be granted, the grantee shall pay rent for so many mill-powers as shall remain * * *; and if such deficiency should happen through the misconduct or willful neglect of the grantors, the grantees shall have a right to recover damages in an action at law against the grantors, in addition to the rent to be withheld as aforesaid.

If any grantee shall suffer damage from want of water from causes not arising from his own neglect or misconduct, and which may be removed or remedied, and the grantors shall, after due notice for that purpose, unreasonably fail to remove the obstructions or remedy the mischief, the grantees injured * * * may * * * remove or remedy the causes of injury; and to pay and indemnify them for the expense and charge thereby incurred, such grantees shall, after the expiration of thirty days from the time the amount of such expense shall have been adjusted * * * have a lien upon all the rents which may have been reserved to the grantors upon the sale of any mill-power, and which may become payable after the expiration of said thirty days, and may * * * demand, sue for, and receive the same until they shall be fully reimbursed as aforesaid.

The grantees are not to use more water than is granted, nor waste it, nor permit it to be wasted, for want of repairs or through the deficiency of their works or otherwise; and if so wasted, or more be used than is granted, the grantors may stop the water from entering their flumes by closing the gates across them, or by any other method, until such waste or excessive use be guarded against; and may also at the same time have their action at law for damages; and other grantees who shall suffer thereby may also have their action at law for damages.

Under these proposals the Essex Company has sold 128 mill-powers, or (as a mill-power is equivalent to a gross power of 85.23 horse-power) 10,909 horse-power. A mill-power was originally valued at about $15,000, and all the original grantees, including all the large corporations on the north side, paid about $10,000 down, and continue to pay an annual interest on the remainder of about 6 per cent., or $300 per annum per mill-power, defined in weight of silver. Of late years, however, the company has leased power for annual payment in currency, without an original cash payment, and all the newer mills, including those on the south side, pay an annual rent of $1,200 per mill-power. This rate is equivalent to $14 08 per gross horse-power per annum.

The following table gives a list of the mills now operated, the power owned by each, and other items of interest, with references to Fig. 7:

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a Two hundred and sixty ounces of silver, as above defined, are equivalent in value to about $300.

Table giving details regarding the mills and power at Lawrence, Massachusetts.

Name of corporation or firm.	Designation on map.	Goods manufactured, or kind of mill.	Number of spindles. (a)	Number of looms. (a)	Water taken, from which canal.	Head and fall.	POWER OWNED.		Steam-power in horse-powers. (a)	Quantity of water in cubic feet, per second. (b)
							Mill-powers.	Horse-powers (gross).		
						Feet.				
Pacific Mills { Main Pacific	a	Cotton, woolen, worsted, etc.	160,500	4,500	North	28±	25	2,131	2,400	666.67
Pacific Mills { Central Pacific	a′						11	938		293.33
Atlantic Cotton Mills	b	Cotton	87,888	1,805	do	28±	22	1,875	500	586.66
Washington Mills	c	Woolen and cotton	15,000	1,404	do	28±	17	1,449	1,000	453.33
Pemberton Mills	d	do	28,000	669	do	28±	12½	1,065	300	333.33
Lawrence Duck Company	e	Duck, felt, and twines	8,000	140	do	28±	5	426		133.33
Everett Mills	k	Cotton and duck	32,096	1,000	do	28±	10	852	200	266.67
Lawrence Woolen Company	f	Woolen	3,280	50	do	28±	1½	128		40
George E. Davis & Son	g	Foundery and grist-mill			do	28±	⅔	57		17.77
Wright Manufacturing Company	h	Braid			do	28±	½	43		13.33
Lawrence Spindle and Flier Works	i	Spindles, fliers, and machine-shop			do	28±	10/12	71		22.22
Dawson & Dustin	j	Leather-board and machine-shop			do	28±	½	43		13.33
Russell Paper Company	l	Paper			do	28±	6⅓	540		168.87
William McAllister	m	Shoddy			do	26±	⅙	14		4.44
Jerome A. Bacon	n	Paper			do	28±	2	170		53.33
Total from north canal			334,764	9,568			115	9,802	4,200	3,066.67
Davis & Taylor	o	Flour and grain			South	28±	2	170		53.33
Munroe Felt and Paper Company	p	Paper			do	28±	3	250		80
Merrimack Paper Company	q	do			do	28±	3	250		80
Butler & Robinson	r	Worsted yarn			do	28±	2	170		53.33
Clegg & Fisher	s	Leather-board			do	28±	2	170		53.33
Union Mill	t				do	28±				
N. W. Farwell & Son	u	Bleachery			do	28±	1	85		26.67
Total from south canal							13	1,108		346.66
Total on both sides of the river			334,764	9,568			128	10,910	4,200	3,413.33

a These data are taken from the "Annual" for 1882, published by the *Lawrence American*.
b The quantity of water is calculated for a fall of 28 feet, at the rate of 26⅔ cubic feet per second per mill-power.

The Union mill, on the south canal, belongs to the Essex Company, which owns the wheel and rents room with power to the Lawrence Line Company, Messrs. Stedman & Smith, machinists, and the Lawrence Electric-Light Company. About two mill-powers are used in this mill.

In addition to the power owned and utilized as above described, a considerable amount of surplus power is utilized by a number of the mills, in accordance with regulations from which the following extracts are made:

I. The use of such surplus water-power shall be permitted to a party desiring to use the same, only on the express condition that it shall furnish the engineer of the Essex Company with all reasonable facilities for ascertaining the quantities used by it, and that it shall comply with such reasonable requirements as he may from time to time make in relation thereto, and with such limitations as to the amount of surplus water-power which it may use, as he, having in view the supply of water in the river, and the respective wants of the different parties using, may deem it expedient from time to time to prescribe; but the limitation so to be prescribed by him shall not restrict a party without its assent to a less quantity of water than would be allowed to it under the general limitation provided for in Article III.

* * * * * * * * *

III. The Essex Company, whenever in their opinion the supply of water renders it expedient as a matter of necessity or precaution, may limit the use of surplus water-power to a certain percentage of the aggregate amount then granted by indenture as aforesaid, but such limitation shall be uniform in its application to all those grantees who shall then have agreed for the use of surplus water-power under these regulations, and shall be in proportion to the number of mill-powers owned by them respectively.

The prices paid for surplus power are as follows, for each day upon which such power is used, viz: For each surplus mill-power or part thereof not exceeding 20 per cent. of the amount owned by the party, at the rate of $4 per mill-power; for each surplus mill-power or part thereof in excess of such 20 per cent., but less than 50 per cent. of the amount owned, at the rate of $8 per mill-power; for each surplus mill-power or part thereof in excess of such 50 per cent., at the rate of $4 per mill-power.

The amount of surplus power used varies with the season. In a dry time its use is sometimes restricted and divided according to Article III, given above. Since the Essex Company has leased power the use of surplus has been limited upon forty days, thirty-four of which were in the fall of 1880 and six in January, 1883. Upon two days only the limitation was as low as 25 per cent., all lessees being then allowed to draw 125 per cent. of the amount of power held by them. Upon the other days the limitation was such as to allow the lessees to draw 140, 150, or 175 per cent. of the amount of power leased. Some of the lessees draw no surplus power, while others draw an amount equal to over 100 per cent. of their regular power. The smallest number of surplus mill-powers used, on the average, during the driest week of the extreme drought of 1880 was 27 (making the total power used

155 mill-powers); and the smallest number used, on the average, during any month has been 35 (making the total power used 163 mill-powers), during working hours. Hence we may take the minimum power of the stream during working hours as 155 mill-powers, or 13,160 gross horse-power. (*a*) The company can still lease a considerable amount of power, but the total low-water power of the stream is now utilized, though to some extent as surplus power. Some mills use steam-power all the time, while others use it only at high water, on account of insufficient wheel-capacity when the fall is diminished. The paper-mills run continuously except Sunday, but in low water are sometimes required to stop during the night; the other mills run sixty hours a week, or about eleven hours on every day except Saturday, in summer, and 10¼ in winter. The mills experience little trouble with ice. The canal often freezes over at night, but is cleared out in the morning before the mills start. The large mills never have to stop for this cause, but some of the small mills at the lower end of the north canal are sometimes obliged to stop for an hour or so.

In the methods adopted in Lawrence for measuring the quantity of water drawn by the different mills, the principle followed is to gauge the quantity every day, some time during ordinary working hours. Accordingly, each mill is visited every day by an inspector, who observes and records the following data: (1) The height of water in the canal at or near the head of the penstock; (2) the height of water in the river; (3) the height of water in the penstock, a short distance above the wheel, read by means of a tube screwed at right angles into the outside of the penstock, and connecting above with a glass tube placed against a scale-board; (4) height of water in the wheel-pit; and (5) height of the speed-gate, all the wheels used being turbines. In order to be sure of the correctness of these readings, the canal and penstock gauges, as well as the pit and river gauges, are periodically compared when the mills are not running, and if the two readings do not agree the error is noted. It may be remarked here that all gauges are intended to be set at the same datum, so that their readings may be strictly comparable without any reduction. In order to be sure that the penstock-gauge tube is freely open, it is periodically tested when the water is drawn out of the canal by pouring water into it.

The difference between 1 and 2 gives the total fall; and for this fall the quantity of water to which the mill is entitled is found in the table giving "quantity of water per mill-power corresponding to fall". If a corporation does not utilize nearly the whole of this fall it is its own fault. The difference between 3 and 4 gives the fall acting on the wheel, and this, together with the height of the speed-gate, affords a means of determining the quantity of water actually used, by comparison with diagrams prepared for the purpose, in a way described below, and which give, for any fall and gate-opening, the quantity passing, there being a diagram for each wheel. The quantity used each day being compared with that to which the mill is entitled, the excess is found and the price for the surplus water determined according to rules already given. The quantities are worked up systematically and with great care.

The diagrams referred to are prepared by making measurements of the quantity of water drawn by each wheel under different heads and at different heights of gate, when the wheels are known to be in good condition, horizontal distances representing quantities of water, and vertical distances heights of gate. In constructing the curves for different heights of fall, due account is taken of the variation of the quantity with the fall and with the relative velocity of the wheel and the issuing water, as well as of the way in which the wheel is set. These measurements are repeated at short intervals of time, to determine if any change has occurred in the amount discharged by the wheels. Such change may be produced by leaves and sticks piling upon the guides, as of the Boyden turbine, or by blocks or bits of coal obstructing the outlets, or by increased leakage between the wheel and its gate or case, or by breakage and loss of a bucket, or by the gate-hoisting apparatus being out of order, or by the wheel-step wearing down. These frequent measurements are also necessary to determine the amount wasted by wheels not in use, and any leakage from the flumes, and the water used for washing and other purposes which does not pass through the wheels. The differences between the results of these measurements and those given by the diagrams is noticed and allowed for in subsequent use of the latter.

Five different methods of making these measurements are or have been in use in Lawrence, which will be considered in order. They all consist in gauging the quantity of water used, the speed-gates being observed at the same time, as well as the height of the water in the penstock and the pit.

1. *Weir measurements.*—In the case of certain mills, weirs are placed on the tail-races, and by observing the height of water on the crest, the discharge is obtained, with due reference to the cirumstances of the case, according to methods which need not be further discussed here.

2. *Flume measurements.*—These, like the weir measurements, are made in the tail-races, and are used for some of the large mills. The velocity at numerous points is obtained by means of loaded poles, the results of the measurements in the flumes being plotted and reduced by methods well known to engineers. (*b*)

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a Since the above was written (February, 1883) the Merrimack river has experienced an unprecedented drought, that of September, 1883, at which time additional limitations were enforced at Lawrence. The flow of the stream averaged at the lowest period about 1,390 cubic feet per second for twenty-four hours of the six working days, being but little in excess of the quantity leased if drawn regularly ten hours a day. The minimum power of the stream during working hours should therefore be now placed at but little over 128 mill-powers, or about 10,867 gross horse-power.

b See Francis: *Lowell Hydraulic Experiments.*

3. *Measurements with the differential tube.*—This instrument is in principle what has been known as Darcy's tube, although some modifications have been introduced in Lawrence. It consists of two small brass tubes, open at the bottom, which are inserted in the current, the lower end of one being turned up stream and that of the other down stream. The tubes connect above with glass tubes fixed on a scale-board, there being diaphragms and stop-cocks between the glass and brass tubes, the former to hinder oscillations of the column, the latter to shut off the columns in the glass tubes and prevent oscillations entirely. The water will stand at different heights in the two tubes, and from the difference of the two the velocity may be determined, if the instrument has been tested beforehand, so that the relation between the velocity and the difference in height is known. The two glass tubes are connected at the top, and an air-pump is used to exhaust the air, so that the water will rise to a convenient height for measurement. The instrument is used by raising or lowering it so as to get the velocity at different depths in a vertical line, the depth of the water being also observed, and then shifting it horizontally so as to get the velocities in different verticals across the current. The mean velocity and the discharge are deduced in a manner similar to that used in flume measurements. When time is not available for a complete series of measurements, the velocity is taken at one point, generally in the center of the section, the ratio of the velocity at that point to the mean velocity in the section being known from previous experiments.

4. Instruments have been devised by Mr. Mills, the engineer of the company, by which he is enabled to observe the velocity simultaneously at twenty-five or thirty points in a cross-section of an open or closed conduit, and they are used in many of the large penstocks for determining the quantity of water flowing; but Mr. Mills wishes still further to perfect these instruments before presenting them to the public.

5. When little water was drawn from the south canal, it was measured by shutting the head-gates of the canal and observing continuously at two points the heights of the surface every half minute for fifteen or twenty minutes, as the wheels drew the water from the canal, thus using the canal as a measuring basin.

From the above description of the methods of conducting the measurements in Lawrence it is evident that the power is one of the most carefully managed in this country. The chief engineer of the company is Hiram F. Mills, to whose unvarying kindness, as well as to that of his assistants, the above information is due.

The drainage area of the Merrimack above Lawrence is about 4,599 square miles, according to my measurements. (*a*)

The Merrimack river is supplied with storage reservoirs in New Hampshire, of considerable size, so that in dry weather the natural flow of the stream may be increased to a considerable extent by drawing on these reservoirs. At the time of the extreme drought of September, 1883, however, no water was being drawn on orders from these sources, although a certain very considerable quantity is always allowed to flow from them, as will hereafter be seen. As these reservoirs are partially controlled in Lawrence, they may be described here.

The Essex Company and the Proprietors of Locks and Canals on the Merrimack river (at Lowell) form together the Lake Winnipiseogee Cotton and Woolen Manufacturing Company, a corporation chartered in 1831, and controlling to a certain extent the storage on a number of lakes in the state of New Hampshire, as shown by the following table:

Storage reservoirs of the Lake Company.

Name.	Area.	Estimated depth that may be drawn.	Remarks.
	Sq. miles.	*Feet.*	
Lake Winnipiseogee and Long bay	71.75	2.5	
Smith's pond and Crooked pond	4.85	4.0	Tributary to lake Winnipiseogee.
Great bay	7.33	2.0	Below lake Winnipiseogee.
Great and Little Squam lakes	11.75	3.5	
New Found lake	7.80	3.0	
Total	103.48		

These reservoirs, being drawn upon during the dry season, contribute greatly to the improvement of all the water-powers below them. They are not drawn upon regularly, and generally water is not drawn upon order during as much as three months of the year, though, at times, several hundred cubic feet per second are drawn. At the time of minimum flow, as remarked above, no water was being drawn.

The lakes named in the above table are shown on the maps of the Winnipiseogee and Pemigewasset rivers. There are dams as follows: At the outlets of New Found and Squam lakes and Smith's pond, at Lake Village (below Long bay), and at Union bridge (below Great bay). At all of these places, excepting at Smith's pond, the company is obliged to allow a certain minimum quantity of water to flow at all times past the dam, so that it is unable to utilize the storage to quite so good advantage as it otherwise might. Some further data regarding the reservoirs will be given hereafter. The following figures, however, have a value in this connection. The reservoirs are drawn from at all times of the year, and during the five years from 1873 to 1878 the total number of days on which water

a Mr. Mills states the drainage area as 4,553 square miles, a result agreeing with mine within the reasonable limits of error.

was drawn from lake Winnipiseogee on orders from Lowell or Lawrence was 226, or an average of 45 days per year. The total depth of water thus drawn was 2.30 feet, or an average yearly depth of 0.46 feet, the maximum in any one year being 0.71 feet, part of which was drawn in January and February, and part in September and October. This shows that the quantity drawn on orders is small, and that if the lake is drawn down 4 feet, as is sometimes stated, it is not all on orders, but part is evaporated, and part goes to supply the mills on the streams below, which must be supplied continuously.

In connection with the flow of the river, reference has already been made to the fact that measurements are being carried on at Lawrence, which will in time afford data for a most valuable history of the flow of the stream. The amount of water flowing over the dam every day is determined by frequent readings of the gauges in the pond. and the profile of the top of the flash-boards, in case such are used, is found by leveling. The greatest depth of water yet observed on the dam is about 10 feet.

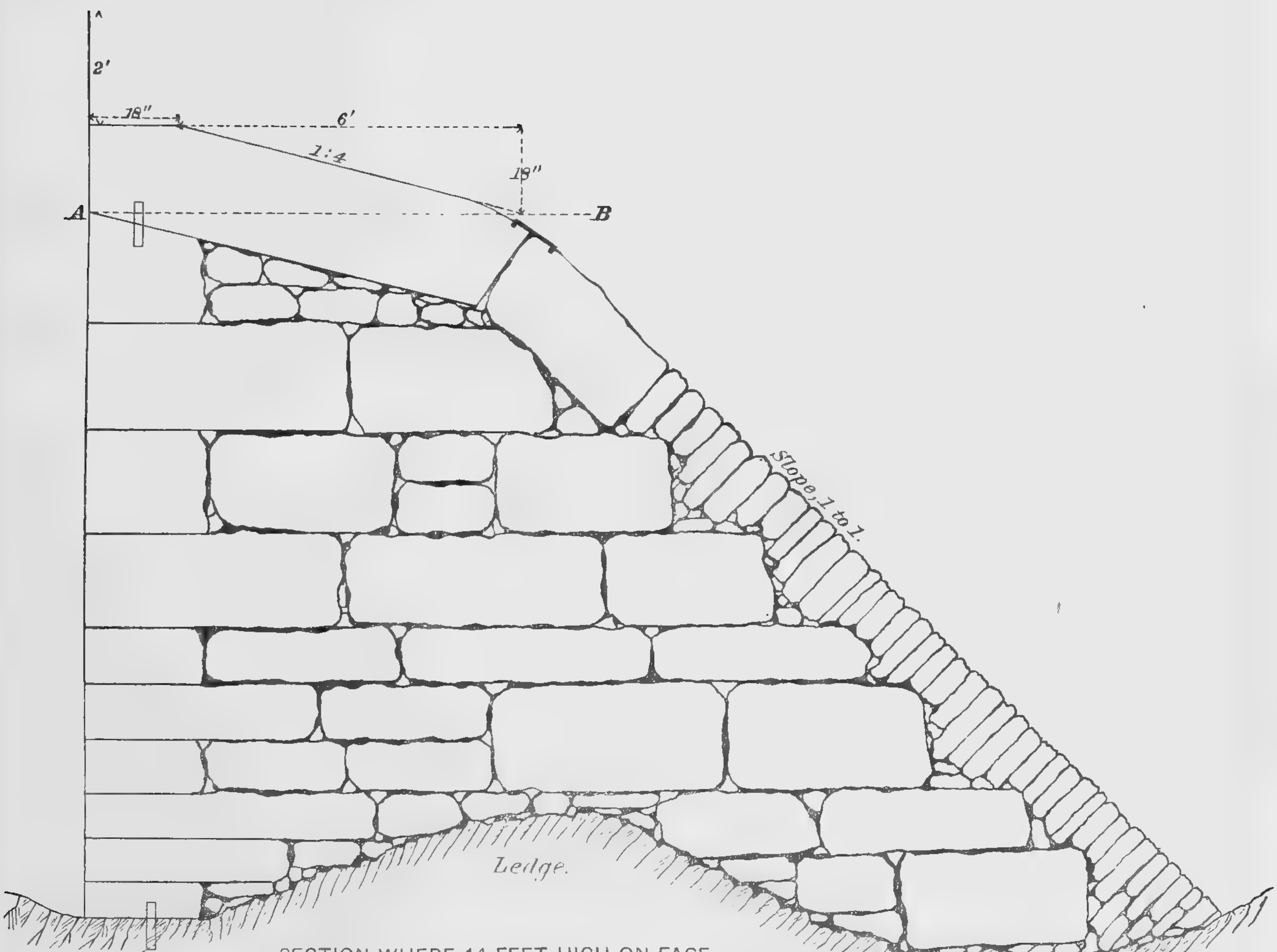
From the top of the Lawrence dam to the top of the Pawtucket dam at Lowell, a distance of about 12 miles, the fall of the river is about 48 feet. Of this fall about 11 feet occurs at Hunt's falls, 9 miles above the Lawrence dam, in a distance of 5,700 feet. This fall is owned by the corporations in Lowell, and will probably never be improved, inasmuch as the construction of a dam there would reduce the fall at the mills above in medium and high stages of the water. The fall is thus of no value as a source of power.

We come, therefore, to the second great power on the Merrimack river, that at Lowell.

THE WATER-POWER AT LOWELL, MASSACHUSETTS.

This power was one of the first of the large powers in this country which was systematically brought into use, and it has been developed and controlled in so admirable a manner that it has long served as a model for other works in various parts of the land. The first step toward the construction of any hydraulic works on the river was taken June 27, 1792, on which date a corporation known as the "Proprietors of the Locks and Canals on Merrimack River" was chartered for the purpose of improving the navigation of the river, and rendering it navigable by boats from tide-water to the New Hampshire line. No dam was built; in fact, the original charter prohibited the building of dams; but the canal known as the Pawtucket canal was built before the year 1800, having been opened in 1796. In 1801 a petition to erect a dam not over 2 feet high was sent to the legislature, but was probably not granted. It would seem, however, that at that time a similar dam was in existence, though only an incomplete structure extending partly across the river. In 1822 the Merrimack Manufacturing Company was incorporated, having purchased a number of farms near the falls. This company, in the same year, enlarged the Pawtucket canal; and although the records are not very clear as to when or by whom it was constructed, it appears that in 1821 there was a wing-dam at the head of the falls, together with a saw- and grist-mill. This dam extended to what is known as Great Rock, and its top was several feet below the top of the present dam. In 1825 there was a temporary dam across the river, and in 1826 the Merrimack Manufacturing Company appears to have made a beginning on a new dam; but in the same year this company transferred all its real estate to the Proprietors of Locks and Canals, who completed the dam in 1830 to 2 feet below its present height (or to 30 feet on the Locks and Canals scale). It was raised 2 feet in 1833 by putting on two courses of granite stone, and its expense up to February, 1833, was about $10,000. As originally constructed, it was built of wooden cribs filled with stone, and with some stone laid as paving below the dam, to prevent its being undermined where it was not built on rock. All of the original stone work, however, was laid without cement, and the gravel filling washed out with every freshet, so that in 1839 the dam had to be tightened by laying a course of masonry in cement at the back of the capping. Flash-boards were used, and in 1840 it was found that the leakage of the dam and flash-boards was 93 cubic feet per second. In 1847 that part of the dam between Great Rock and the gate-house was rebuilt in its present position to conform to the entrance to the northern canal, which was built during that and the previous year (1846). Its top was level, and at a height of 32 feet on the Locks and Canals scale; and its section is similar to that in Fig. 8. The lowest course in the face is doweled to the foundation, which is solid rock, and the capping-stones are doweled together and to the course below. The capping-stones and the slope-stones behind them are clamped together. The ashler work and granite backing were laid without cement—the mortar-stone backing and leveling in cement; the joints in the capping were filled with sulphur. In 1869 the directors considered the propriety of rebuilding the remainder of the dam, from Great Rock to the north side of the river, but it was not decided to commence the work till February, 1875. The new dam was built on nearly the same site as the old one, and its section is shown in Fig. 8. The rock foundation is stepped off to receive the ashler work, and the stones were laid at first without cement in beds or joints, and then grouted, course by course, with pure Portland cement. The backing is laid in a mortar consisting of equal parts by measure of the Newark Lime and Cement Company's cement, and clean, sharp sand. This was done to provide for possible disintegration and loss of cement, at and near the face of the dam, from the action of water and frost. As it is, the bearings will not be affected by the failure of the cement. In the portion of the dam built in 1847 the ashler was laid without cement in any form, with the same object; but some of the stretchers have worked out, to prevent which occurrence the new dam was grouted. The bed and joints of the capping, up to the level A B, were grouted with Portland cement in the same

Fig. 8. SECTION OF DAM AT LOWELL, MASS.



SECTION WHERE 14 FEET HIGH ON FACE.

Where the dam is more than 14 feet high, the part below 14 feet from the top is 20 feet thick, except at the "deep place."

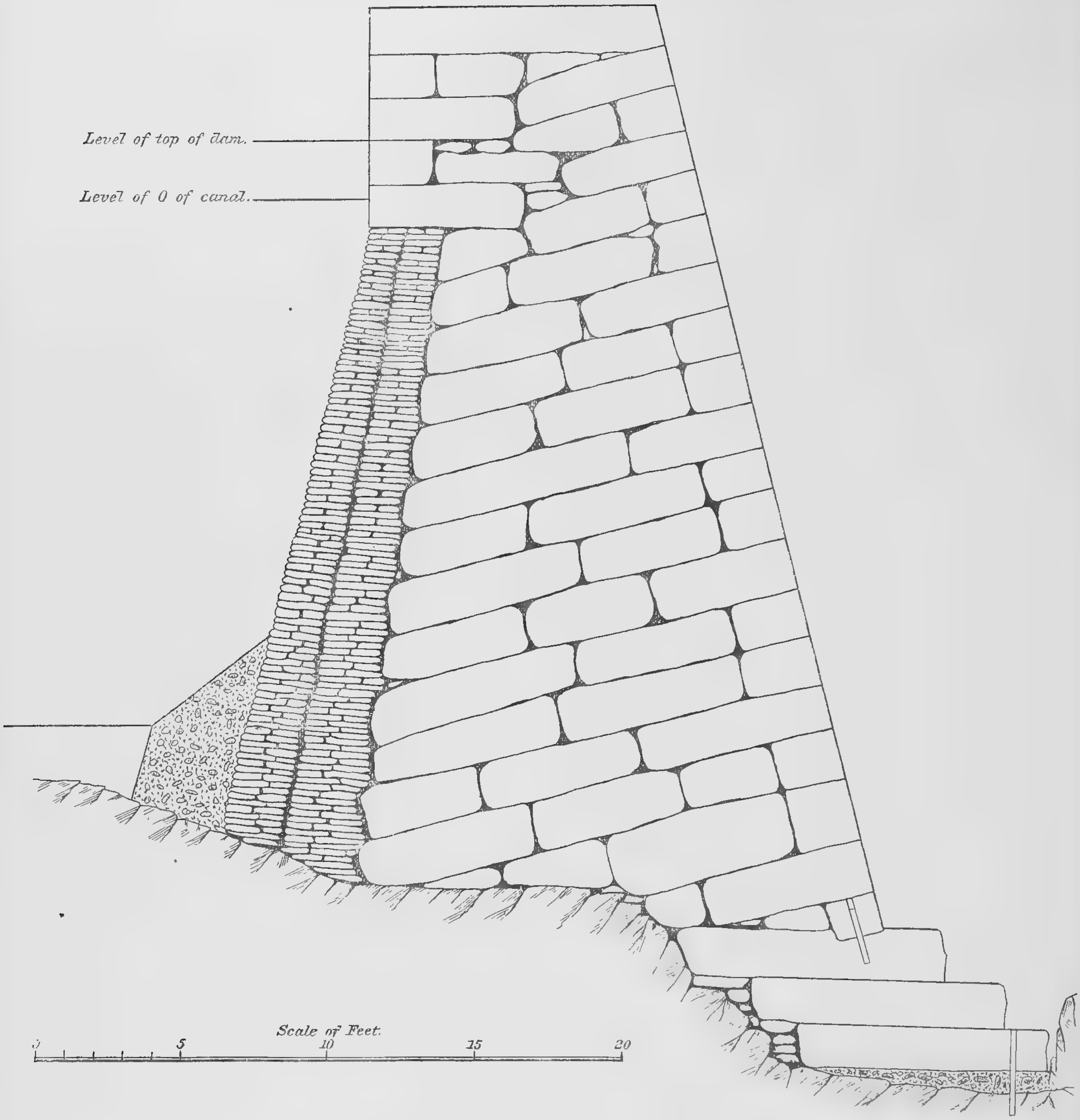


Fig. 9.

SECTION OF GREAT RIVER WALL AT LOWELL, MASS.

1326 feet from north side of Pawtucket Bridge.

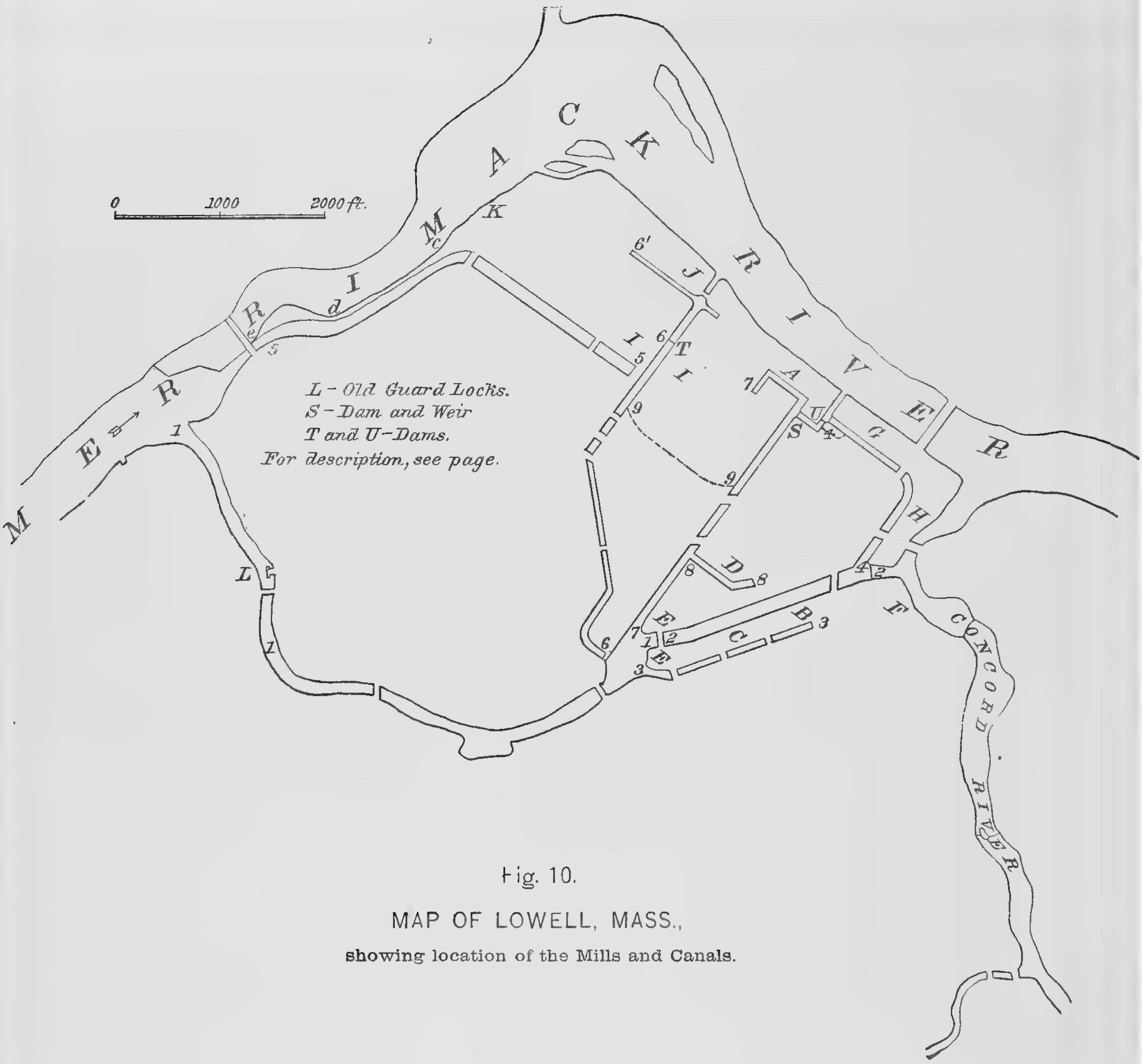


Fig. 10.

MAP OF LOWELL, MASS.,

showing location of the Mills and Canals.

manner; above A B the joints and the 1¼-inch iron dowels of the capping were filled with melted sulphur. The crest of the dam (18 inches wide) is fine-hammered, and designed to be at the exact mean height of the dam of 1847; above this, as in the old dam, there are flash-boards 2 feet high. In what is called "the deep place", at the lowest point of which the bed is 38.3 feet below the top of the dam, the foundation was prepared for the ashler work, for a distance of 100 feet, by leveling up with rubble masonry in cement to a height of 20.66 feet below the top of the dam. Great Rock was cut down and capped with granite in 1875, and First and Second rocks in 1876. The total length of the dam is 1,093.5 feet, its height varying from 2 feet or so, on the north side of the river, to 16 feet, excluding "the deep place". Its crest is at 32 feet, and the top of the flash-boards at 34 feet, on the company's scale. It extends in a very broken line up stream, often quite in the direction of the current, its south end being 700 or 800 feet below its north end. The total cost of rebuilding the dam in 1875 and 1876 was $104,056 75; that of building the dam of 1847 was about $10,000, making the total cost of the dam about $114,000. The works were carried out under the supervision of Mr. J. B. Francis, the present agent and engineer of the company, whose connection with the company commenced November 22, 1834, and has since been uninterrupted. (*a*)

The dam deadens the current, in the ordinary state of the river, for about 18 miles, forming, in low water, a reservoir of about 1,120 acres, which is sufficient to store the low-water flow of the river during the night-time, allowing the entire daily flow of the stream, during the dry season, to be utilized during ordinary working hours, as at Lawrence. The dam is situated at the head of what are known as Pawtucket falls, and for a distance of half a mile below the gate-house the bed of the stream is solid rock, the fall rapid, and the banks high and rocky. Two canals lead the water from above the dam, the original Pawtucket canal, enlarged in 1822 and 1823, and the northern canal (see map), both on the south side of the river. Various other canals intersect these two, all of which are shown on the accompanying map of Lowell (Fig. 10), and regarding which data are also given in the following table:

Canals at Lowell, Massachusetts. (*a*)

Name.	Designation on map.	Section.	Length (approximate).	Depth (approximate).	Width (approximate).	On what level.
			Feet.	*Feet.*	*Feet.*	
Pawtucket:						
Upper level	1–1	Irregular	6,500	10	Irregular.	Upper.
Lower level	2–2	Rectangular	2,200	7	100	Lower.
Hamilton	3–3	....do	1,600	10	50	Upper.
Eastern	4–4	....do	2,000	8	42 to 66	Lower.
Northern	5–5	.. do	4,100	16 to 21	100	Upper.
Western	6–6	....do	3,500	10	15 to 115	Do.
Do	6–6′	....do	1,000	8	30 to 80	Lower.
Merrimack	7–7	Rectangular and irregular.	3,400	10	50	Upper.
Lowell	8–8	Rectangular	500	10	30	Do.
Moody-street feeder	9–9	Rectangular and arched over.	1,390	*b* 10	30	Do.

a Total length of canals, about 5 miles. Bottom of lower level, at about 9 feet on scale. River behind mills, at low water, at about 2 feet on scale. Water surface, lower level, at about 17 feet on scale. Bottom of upper level, at about 22 feet on scale. Water surface, upper level, at about 32 feet on scale.

b In middle of arches.

These canals are in many respects extremely interesting from an engineering point of view. With the exception of the Moody-street feeder, they are all open, and generally rectangular in section, only the upper level of the Pawtucket canal and the Merrimack canal being irregular in places. The Moody-street feeder, which was built through Moody street to connect the western and the Merrimack canals, is an underground conduit, divided into three parts by two longitudinal walls, forming the piers for three arches, which close the conduit on top. It is 1,390 feet long, and each of the three sections is 10 feet wide in the clear, and 7 feet high from the floor to the springing of the arches. The latter are of brick, 1 foot thick, and segmental, the radius being 5 feet 8 inches and the rise 3 feet. The side walls are 2½ feet thick, and the piers 15½ inches at top, spreading to 23 inches at the bottom. The feeder cost $86,131 81, or about $62 per running foot. The northern canal was built at great cost, being separated from the river, for a distance of about a quarter of a mile, between *c* and *d* on the map (Fig. 10), by a great river-wall of masonry, in places 36 feet high, and a section of which is shown in Fig. 9. This wall is founded on ledge, and is provided with four large and two small sluice-openings, for emptying the canal, together with an overflow. Between *d* and *e* on the map the canal is excavated, but a wall is carried down to the ledge, on the river side. The total cost of the northern canal was $551,584 70. The head-gates of the northern and the Pawtucket canals are all worked by hydraulic power. Those of the former are ten in number, each 8 feet wide, and filling an entire opening between piers. The lift is 15 feet, making the area of gate-opening 1,200 square feet, and they are raised by means of a small turbine wheel which drives a line of shafting, from which, by means

a It is a pleasure to acknowledge here my great indebtedness to Mr. Francis and his assistants for the information contained in these pages, and for revision of the manuscript.

of belts, the hoisting apparatus is driven. At the Pawtucket canal the gates are five in number, 9 feet long and with a lift of 10 feet, making the area of gate-opening 450 square feet. They are raised by being attached directly to a piston, which is raised by hydraulic pressure obtained from the water-pipes from the company's private reservoir. The details of these gates are worthy of careful study.

The fall at Lowell, at ordinary low water, is about 35 feet, of which about 2 feet is lost in consequence of the descent in the canals, leaving a net fall of about 33 feet. In severe freshets, however, the water below the mills rises 10 or 12 feet, and it has been (in 1852) 13 feet 7 inches deep on the dam; the fall, therefore, varies between about 33 and 20 feet. About one-sixth of the water is used on the entire fall, and the remainder is used twice over, on falls of about 14 and 19 feet, respectively. The lower fall, however, was reduced to 3 feet in 1852, the water rising in the river to 14 feet on the scale; and in 1878 the water rose to 10 feet, the fall being only 7 feet. Such cases, however, are, of course, extremely rare.

The water-power of the Merrimack at Lowell is owned, as has already been stated, by the Proprietors of Locks and Canals on Merrimack River, what is called the "permanent power" being held by the manufacturing companies under perpetual leases. The capital stock of the Proprietors of Locks and Canals is held entirely by the ten large manufacturing corporations using the power, in proportion to the permanent power held by them, respectively. The power, therefore, unlike that at many other places, is controlled by the very parties who use it, and by no others, and is not leased or sold by other and different parties, though managed by a quite distinct corporation. It may be expected, therefore, that the price of water-power in Lowell should be very low, and this will be seen to be the case. The water-power has been granted by the Proprietors of Locks and Canals in definite quantities, called mill-powers, as in Lawrence, but in this case a mill-power is defined to be

> The right to draw from the nearest canal of the said Proprietors so much water as, during fifteen hours in every day of twenty-four hours, shall give a power equal to 25 cubic feet per second at the great fall when the head and fall there is 30 feet, to 45.5 cubic feet per second at the lower fall when the head and fall there is 17 feet, and to 60.5 cubic feet per second at the middle fall when the head and fall there is 13 feet. And in order to prevent disputes as to the power of each mill-privilege in the variations of the height of water from changes of the season or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the *reduction* of the height, * * * one foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them.

This method of determining the quantity of water is similar to that used in Lawrence; thus, when the head and fall (from canal to river) is 29 feet at the great fall, the quantity of water is $\frac{29}{28}$ of 25 cubic feet per second, the quantity of water being increased on account of the smaller fall, not in the proportion of 30 to 29, but in that of 29 to 28. We may also find the quantity by dividing 725 by the fall minus 1 foot. It is important to notice, however, that if the falls are more than those stated in the quotation above (*i. e.*, 30 feet on the total fall—13 feet on the upper level, and 17 feet on the lower level), no change is made in the quantity of water allowed, so that the mills obtain gratis the benefit of any additional fall. Now, although at the time the leases were made the fall from the upper level to the lower, and that from the lower level to the river, were respectively 13 and 17 feet, the canal walls have been raised since that time, so that the actual falls now are 14 and 19 feet. In the table on page 33, the smaller falls, which may be called the nominal falls, are given, while the actual falls are added in parentheses. Tables are prepared, as in Lawrence, giving the quantity of water per mill-power corresponding to fall. The Proprietors are to maintain the dam and canals, while the flumes and raceways are to be kept in order by the corporations. The Proprietors are not bound to furnish power between the hours of 8 p. m. and 5 a. m. The lease contains various other stipulations, regarding injury from lack of water, rights of the Proprietors to measure the quantity of water used, liability of either party to damages under certain circumstances, etc., which, however, are so nearly like those which have been already quoted as being in use in Lawrence, that it is not necessary to give them in detail. The permanent power, as already stated, is held under permanent leases, but with a reserved rent, as at Lawrence, the object of which is to provide for the management of the same and the maintenance of the works. This reserved rent for the permanent power is fixed at \$300 per mill-power per annum, or (as a mill-power is equal to about 85 gross horse-power) at \$3 53 per gross horse-power per annum, which is only sufficient to cover the necessary expenses of maintaining the power. Cash payments were made when leases were given, averaging about \$10,000 per mill-power.

The following list gives the names of the corporations now owning power, as well as the amount owned by each, together with various other details:

Table giving details regarding the mills and power at Lowell, Massachusetts.

Name of corporation.	Designation on map.	Goods manufactured	Number of spindles. (*a*)	Number of looms. (*a*)	Water taken from—	Water discharged into—	Head and fall in feet. (*b*)	POWER OWNED. Mill-powers.	POWER OWNED. Gross horse-power.	Steam-power in horse-power. (*a*)	Quantity of water in cubic feet per second.	No. shares in Proprietors of Locks and Canals.
Merrimack Manufacturing Company.	A.	Cotton	153, 552	4, 267	Merrimack canal	Merrimack river	30 (33. 5)	$24\frac{20}{30}$	2, 097	6, 000	616. 667	740
Hamilton Manufacturing Company.	B.	...do	59, 816	1, 597	Hamilton canal	Lower level of Pawtucket canal.	13 (14)	16	1, 360	1, 200	968. 000	480
Appleton Company	C.	...do	45, 000	1, 228	...do	... do	13 (14)	$8\frac{16}{30}$	725	750	516. 267	256
Lowell Manufacturing Company	D.	Cotton and woolen	22, 750 (worsted and wool). 2, 000 (cotton).	317 (power carpet). 75 (lasting).	Merrimack canal	...do	13 (14)	$8\frac{12}{30}$	714	1, 040	508. 200	252
Lowell Machine Shop (*c*)	E.				Merrimack canal and Machine-shop basin.	... do	13 (14)	$3\frac{9}{30}$	280	375	199. 650	99
Middlesex Company	F.	Woolen	18, 640	250 (broad).	Lower level of Pawtucket canal.	Concord river	17 (17)	$5\frac{23}{30}$	490	125	262. 383	173
Boott Cotton Mills	G.	Cotton	127, 000	3, 600	Eastern canal	Merrimack river	17 (19)	$17\frac{23}{30}$	1, 519	1, 000	812. 933	536
Massachusetts Cotton Mills	H.	...do	119, 528	3, 658	... do	Merrimack and Concord rivers.	17 (19)	$24\frac{16}{30}$	2, 085	950	1116. 267	736
Tremont and Suffolk Mills	I.	... do	94, 000	2, 700	Northern canal	Lawrence basin	13 (14)	13	1, 105	1, 500	786. 500	390
Lawrence Manufacturing Company.	J.	... do	100, 000	2, 360	Lawrence basin	Merrimack river	17 (21)	$17\frac{9}{30}$	1, 470	1, 000	787, 150	519
Total			742, 286	20, 052				$139\frac{11}{30}$	11, 845	13, 940	[illegible]	4, 181

a These data are from *Annual Statistics of Manufactures in Lowell and Neighboring Towns, January*, 1882. Published by the Lowell *Vox Populi*.
b Figures in parentheses are actual falls (see page 32).
c This establishment consumes per year 1,100 tons wrought-iron, 8,500 tons cast-iron, and 200 tons steel—in all 9,800 tons of metal.

It appears, therefore, that there are sold at Lowell, in all, $139\frac{11}{30}$ mill-powers, or 11,845 gross horse-power on the original leases. As giving a further idea of the magnitude of the mills, it may be mentioned that the total capital invested in the ten corporations named in the table is $13,950,000, and the total number of operatives employed, 16,665. The quantity of water taken from the river, when no surplus is used, is 3,595.284 cubic feet per second, during working hours, under the normal falls. Of this, 616.667 cubic feet are discharged directly into the river, 786.5 into the Lawrence basin, and the remainder, or 2,192.117 cubic feet, into the lower level of the Pawtucket canal. The quantity taken from this last canal and discharged into the river is 2,191.583 cubic feet per second, while from the Lawrence basin 781.150 cubic feet are taken. It is clear that the water is utilized almost absolutely without waste.

As in Lawrence, a large amount of surplus power is used in Lowell, in accordance with regulations, from which the following extracts are made:

1. Any company who shall use any of such surplus power, but to an extent not exceeding 40 per cent. of the whole number of permanent powers that such company is now entitled to use, shall pay therefor, as a contribution toward the annual expenditures of said Proprietors, $5 per mill-power per day for the time that each power or part thereof shall be used.

2. In order to restrain the use of such surplus power, any company that shall be found to have used more of it than 40 per cent. of the powers so held and owned by such company, shall pay for all excess over 40 per cent. thereof, and not exceeding 50 per cent. thereof, at the rate of $10 per mill-power per day; and for all excess over 50 per cent. thereof, and not exceeding 60 per cent. thereof, at the rate of $20 per mill-power per day; and when more than 60 per cent excess is used, such company shall pay for the whole amount of surplus power used by it, at the rate of $20 per mill-power per day.

As in Lawrence, the engineer of the Proprietors can make measurements of the quantity used by each mill as often as he sees fit, and can limit the amount of surplus power to be used, having in view the supply of water in the river, "such limitations to be uniform in their application to all said companies, and to be in proportion to the mill-powers owned by them respectively." If, during the time when such limitations are in force, any company shall use a quantity of water in excess of that to which it is limited, said company shall pay for the same at the rate of $75 per mill-power per day for the greatest excess used on each day. Quarterly reports are made and accounts sent in to the different companies.

6. During *backwater* a uniform rate of $1 per mill-power per day shall be paid, and it shall be considered "backwater" when the height of the water in the river at the gauge back of the mills of the Merrimack Manufacturing Company is at or above 1 foot below zero, excepting when the water is raised to that point, or above, by ice.

In dry weather little or no surplus is used, while during "backwater" large amounts are used, some companies using up to 75 per cent. of what they own. In the fall and winter of 1880 and 1881 all the mills were limited in its use, and for twenty-eight days during that period its use was prohibited. The greatest amount of surplus used when there is no backwater is about 30 or 40 per cent. of the power owned. The minimum power available during working hours is consequently entirely utilized, although during a great part of the year some water goes to waste.

As a rule, even in low water, water flows over the dam early in the morning, but sometimes there is no waste whatever. We may, therefore, take the minimum power of the stream, during working hours, as $139\frac{11}{30}$ mill-powers, for the companies have never failed to obtain, with the aid of the lakes in New Hampshire, the full power they own. (*a*) A large amount of steam-power is used, as the table shows; some all the time, some only when surplus water is too expensive. The mills run from 6.45 a. m. till noon, and from 1 till 6 p. m., stopping at 4.30 on Saturdays, making sixty hours per week, the legal limit for the employment of women and children in factories. As in Lawrence, arrangements are made for disposing of ice, and there is little interruption of work caused by it.

It remains to describe the system of measuring water used at Lowell for the purpose of determining the quantity used by each mill. The method adopted is in most essential particulars the same as that used at Lawrence, though differing in many matters of detail. The idea is to get a direct measurement of the quantity of water used by each mill during a certain period—say a week—when the rate of running remains about the same. If anything occurs to alter the quantity of water consumed a new measurement is made. But it is recognized that the quantity of water used varies continually during the period chosen, according to the hour of the day and the day of the week, being greatest on Monday morning and least on Saturday afternoon. Accordingly, during the period taken, not one measurement, but four, are usually taken; one on a Monday morning, one on an ordinary morning, one on an ordinary afternoon, and one on a Saturday afternoon. The excess or surplus used above the power owned at each of these times is calculated, the fall from canal to river having been simultaneously observed. That on Monday morning added to that on Saturday afternoon, and to five times that on ordinary mornings and afternoons, if divided by 12, gives the average surplus used, and this is taken as the surplus used during the whole period considered.

In addition to these measurements, which are made, perhaps, rather more frequently than in Lawrence, daily records are made in Lowell of the heights of water at each mill in canal, penstock, wheel-pit, and river, together with height of speed-gate; but these observations are not used in working up the daily quantity of water discharged, as they are in Lawrence, except in unusual cases. For instance, if something occurs in one of the mills which necessitates stopping one wheel for a few days and substituting another, or if in any way the regular rate of work is interrupted for a short time, during which a flume measurement cannot be made, then the daily observations are used to determine the quantity used during said time of interruption; said quantity being obtained, not from diagrams, but from tables giving similar results. These tables are computed as follows: For each wheel the area of bucket-opening and the area of guide-opening are found by measurement. The smallest of these being called A, the quantity of water discharged under a given head, h (from penstock to wheel-pit, as in Lawrence), is calculated by the following formula:

$$Q = m\,A\,Q_r\,\sqrt{2\,gh}$$

in which m is a coefficient known by experience, g the acceleration due to gravity (32.2 feet per second), and Q_r the ratio of the discharge at any given opening of gate to that at full gate. This ratio is found for different gate-openings by actual test of the wheel, or by comparison with results of tests on similar wheels. The table gives, therefore, the discharge for different gate-openings under a given head, h, from penstock to wheel-pit. For any other head the quantity is assumed to vary as the square root of that head.

These tables are used in the following cases:

1. When, as above noticed, the regular running is interrupted for a short time, during which a standard measurement cannot be made.

2. Whenever it is *backwater*, in which case the fall is varying continually, water is very cheap (see page 33), and great accuracy is not so essential.

3. In times of low water, when the use of power is limited, and when, in addition to the ordinary standard measurements, it is necessary to calculate the quantity at frequent intervals. In such cases observations are made several times a day and the tables used.

Just as the diagrams in Lawrence must be tested at periods by comparison with the results of measurements, so these tables must be checked at every opportunity. Before explaining how this is done, we must describe the measurements in use in Lowell. These are only of three kinds—weir, orifice, and flume. One weir and one orifice measurement only is made, in connection with the Lawrence Manufacturing Company, which uses the water from the Tremont and Suffolk mills, together with an additional quantity which is admitted to the Lawrence basin

a Since the above was written (February, 1883) the extreme drought which occurred in September of that year, and which has been already referred to in describing the power at Lawrence, has rendered it necessary to modify the above statements. During that drought, for a period of about a month, the flow of the river reached a lower point than ever known before, falling to about 1,275 or 1,300 cubic feet per second (during twenty-four hours) on the worst day, as has already been noted in the table on page 9. During this entire period no water was drawn from lake Winnipiseogee, on account of its low stage, except what is lawfully required to be allowed to run, and the use of surplus water was prohibited in Lowell for a longer period than at any previous time since the establishment of the power.

through gates which have been experimented upon, and for which the coefficients are accurately known. The quantity used by the Tremont and Suffolk mills is measured, also that which goes through the gates and that which flows over the waste-weir of the Lawrence basin. In this way the quantity used by the Lawrence Company is obtained. All the other measurements are flume measurements, made nearly as in Lawrence. An important point of difference, however, is that in Lowell there is no space behind the mills allowing the measurements to be made in the tail-races; in fact, the mills are built almost over the water, so that the measurements have to be made in the main canals. They are made at regular times, and the velocity taken every foot and a half across the flumes. Simultaneously with these measurements (except on Monday mornings and Saturday afternoons, when the fluctuations of power are great) the speed-gate gauges, and the heights of water in penstock and pit, and canal and river, are observed. We have seen that in Lawrence a diagram is obtained generally for each wheel, though this has sometimes to be done indirectly, and this diagram is tested by the periodic measurements. In Lowell, however, as the measurements are made in the canals, and not in the tail-races, the total quantity of water used by each mill is what is obtained. Each flume measurement, therefore, applies only to some particular combination of wheels which happen to be running at the time of the measurement. For every flume measurement, then, except those on Monday morning and Saturday afternoon, a coefficient or correction is found, to be applied to the wheel tables, and a large number of coefficients has been thus obtained, applicable to various combinations of wheels running; so that in any case when the wheel tables have to be used, the proper coefficient is sought out from among the most recent ones, as nearly as may be.

One other point remains to be noticed. Some of the mills use wheels which have been carefully tested under various heads, gates, and speeds. In such cases the daily observations of head and gate are probably as accurate as flume measurements would be; and the quantity of water passing such wheels is determined by observing, as in flume measurements, during the period when the power used is about constant, the quantity passing some Monday forenoon, some Saturday afternoon, and on some ordinary forenoon and afternoon.

We may sum up briefly, as follows, the principal differences between the methods of measurement in Lowell and Lawrence:

1. In Lawrence, the measurements are made in the tail-races; in Lowell, generally in the canals.

2. In Lawrence, reliance is placed on the wheel diagrams, which are checked at intervals by standard measurements, and the daily quantity is calculated; in Lowell, the wheel tables are only resorted to in exceptional cases, and reliance is placed on the mills running at a uniform rate during certain periods, during which the average quantity is calculated directly from measurements.

3. In Lawrence, flume, weir, and piezometric measurements are made; in Lowell, mainly flume and weir measurements.

The drainage basin of the Merrimack above Lowell comprises an area of about 4,085 square miles, according to my measurements, the principal tributary between Lowell and Lawrence being the Concord.

The Lowell mill-pond extends to the foot of Cromwell's falls, 4¼ miles above Nashua and 17¾ miles above the Pawtucket dam. From this point up to Manchester, New Hampshire, a distance of about 13 miles, the river rises about 33 feet. In this distance there are several descents honored by the name of falls, but none of them are of much value for water-power, and will scarcely be improved. The following table gives details regarding them: (*a*)

From—	To—	Rise.	Distance.
		Feet.	*Feet.*
Foot of Cromwell's falls	Foot of Moore's falls	5.75	28,532
Foot of Moore's falls	Foot of Little Cohass falls	8.55	12,500
Foot of Little Cohass falls	Foot of Goff's falls	4.50	5,900
Foot of Goff's falls	Foot of Short falls	5.69	4,400
Foot of Short falls	Foot of Griffin's falls	4.03	5,300
Foot of Griffin's falls	Foot of Merrill's falls	2.08	10,800
Foot of Merrill's falls	Head of Merrill's falls	2.56	1,250
Foot of Cromwell's falls	Head of Merrill's falls	33.16	68,682

THE WATER-POWER AT MANCHESTER, NEW HAMPSHIRE.

We now come to the third of the great powers on the Merrimack, and one which will hold its own with the two already described. A log dam across the river at Amoskeag falls existed prior to 1809, the power created being used for a grain- or a saw-mill. A cotton-spinning mill was built on the west side, and was also run by water from this dam. In 1825 a second mill was added to this, and a third was built on an island in the river. All these mills were run thenceforward in the manufacture of tickings until they were burned, in 1840 and 1847.

The Amoskeag Manufacturing Company was formed in 1831, and purchased these mills, the water-power, and several thousand acres of land, on which the city of Manchester has since been built. In 1837 this company

a Senate Ex. Doc. No. 45, Forty-seventh Congress, first session, p. 12.

replaced the log dam with a stone dam, and built about 4,000 feet of its upper canal, on which, in 1838, a cotton-mill was built. Between that time and 1845, this canal was built as it now is, and the lower canal was added. The erection of mills on these canals has continued to the present time.

The present dam, constructed in 1871, a little farther down the river than the old one, consists of two parts—the wing and the main dam. The former commences at the gates at the head of the canal, and extends up-stream nearly parallel to the east bank, ending at a large rock or ledge a little to the east of the middle of the river. It is perfectly straight. Its length is 260 feet and its average height 10.92 feet. It is founded entirely on ledge of coarse mica-schist and granite. The main dam extends from the upper side of the rock at the end of the wing, up and across the river to the gates of the small canal on the west bank. It is curved up-stream in an irregular curve, its length being 420 feet and its average height 11.85 feet. It also is founded entirely on ledge. The wing-dam was rebuilt in 1870 and the main dam in 1871, and the cost of both was $60,000. They are the same in construction, and are built of hammered granite laid in cement. Their section is shown in Fig. 11. The crest is perfectly level for a foot in width, and its height is 70 feet on the Manchester scale (for its height above tide, see page 24). It is drilled every 4 feet 8 inches for wrought-iron pins 1½ inch in diameter, for holding on flash-boards to a height of 2 feet. The face batters 2 inches to the foot, and the back 1 inch to the foot. The ledge on which the dam stands is leveled off in steps to receive it.

Canals lead from the dam on both sides of the river. That on the west side is only about 100 feet long, 20 feet wide, and 8 or 10 feet deep, supplying only the paper-mills of the P. C. Cheney Company. On the east side there are two levels. The upper canal is about a mile long, rectangular in section, varying in width from 50 to 70 feet, and in depth from 10 to 12 feet. The lower level is about 7,250 feet long, rectangular in section, its width varying from 40 feet at the head to 60 feet at the lower end, and the depth from 8 to 10 feet. The map shows these canals and the locks at the head. The head-gates are twenty-four in number, arranged, as in Lawrence, in six sets of four each. The gate-openings are each 10 feet high and 8 feet 10½ inches wide, making the total area of gate-opening 532½ square feet. The gates are raised by a turbine wheel, running a shaft from which the gates are operated by means of bevel-wheels. The Manchester dam backs the water about 8 miles up to Hooksett, the average width of the pond being about 450 feet, and its area measuring about 443 acres. This pond is sufficient in dry weather to allow of the water being stored during the night-time and the entire flow utilized during working hours, so that in very dry weather it sometimes occurs that no water flows over the dam for days at a time. Generally, however, there is some waste toward morning, and sometimes during the day-time, even during the summer. The flash-boards are kept on almost all the time, but are sometimes carried off by the ice and high water. The dam is built at the head of the Amoskeag falls, and the principal fall occurs below it. The fall from the upper to the lower canal is about 21 feet and is nearly constant; that from the lower level to the river is from 29 to 31 feet at low water near the lower end of the canal, and about 34 feet at its very foot. At ordinary high water this fall is reduced to about 25 feet. The power is controlled by the Amoskeag Manufacturing Company, which has disposed of a portion of the power in accordance with proposals from which the following extracts are made, the power being leased by the mill-power:

II. Each mill-power at the respective falls is declared to be the right to draw from the nearest canal or water-course of the grantors, * * * 38 cubic feet of water per second at the upper fall, when the head and fall there is 20 feet—or a quantity inversely proportionate to the height at the other falls—and in order to prevent disputes as to the power of each mill-privilege in the variations of the height of water from changes of the season or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them.

This rule is the same as dividing 722 by the fall minus 1 foot, in order to find the quantity. A mill-power is therefore equivalent to 86.36 gross horse-power. The Amoskeag Company is to maintain the dam and main canal, while the flumes and raceways are property of the parties leasing power.

V. Every purchaser is to hold his purchase subject to the right of every prior grantee in case of a deficiency of water, but the grantors warrant a sufficient water-power existing at the time of the sale to each grantee, respectively.

As at Lowell and Lawrence, the power granted is held by perpetual leases, with a reserved perpetual annual rent per mill-power, defined in this case as at least sixteen and one-eighth ounces troy weight of gold of the present standard fineness and weight of the gold coin of the United States, or an equivalent in gold, at the option of the grantee at the time of payment. This is equivalent to about $300 per annum. Other terms of the proposals resemble so closely those which are in use in Lawrence and Lowell, and which have been quoted, that it is not necessary to repeat them. It is only to be added that, excepting 35 mill-powers, granted at first by lessees, power is only to be used during sixteen hours each day, viz, from 4 o'clock a. m. until 8 o'clock p. m. It will be seen that the annual rent is nearly the same as in Lowell, and for the large mills in Lawrence, being here $3 47 per annum per gross horse-power.

Under these proposals the Amoskeag Company has disposed of its power as shown in the following table, similar to those which have been given for Lowell and Lawrence:

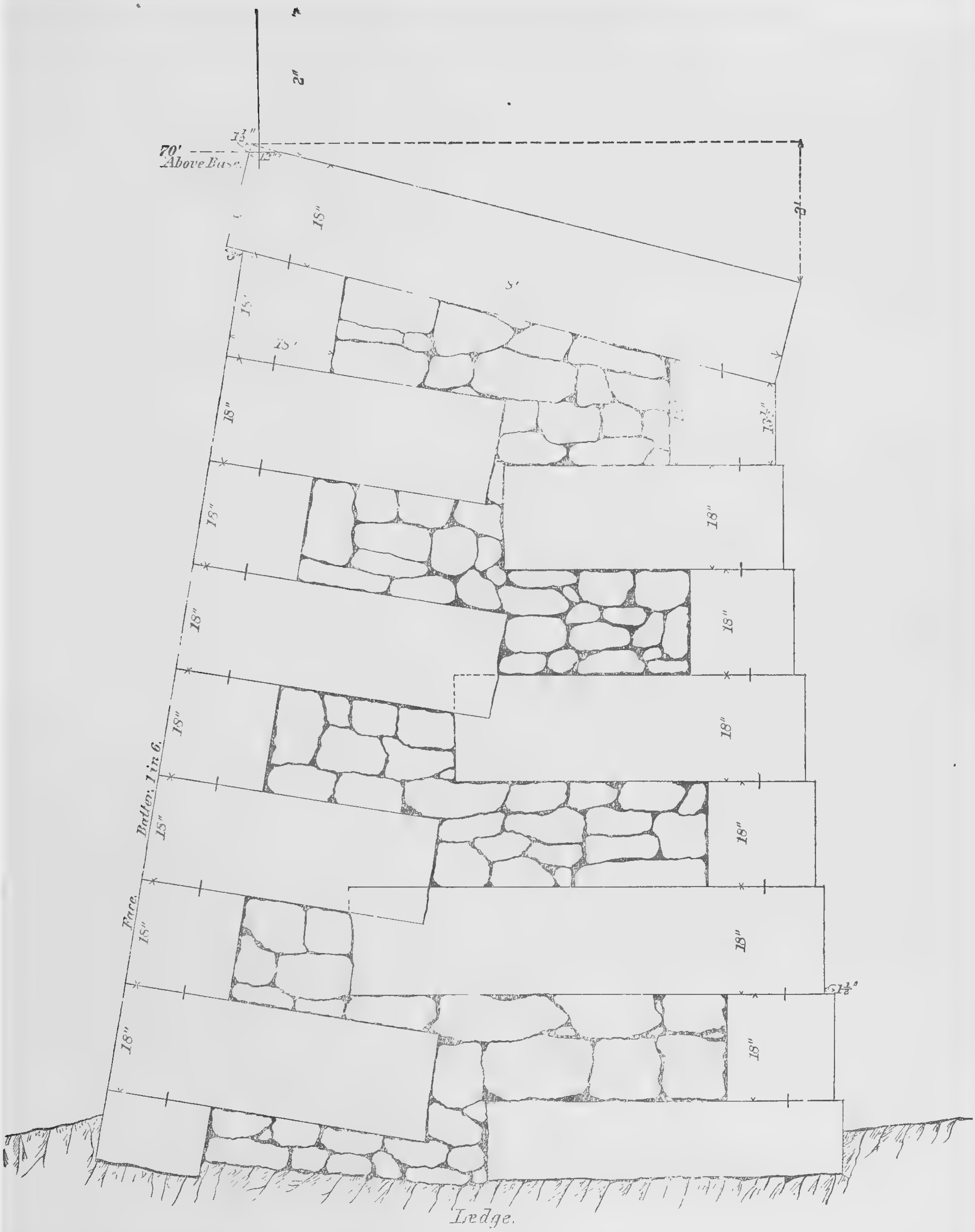


Fig. 11. SECTION OF DAM AT MANCHESTER, N. H.

Table giving details regarding the mills and power at Manchester, New Hampshire.

Name of corporation or firm.	Designation on map.	Goods manufactured.	Number of spindles.	Number of looms.	Water taken from—	Water discharged into—	Head and fall.	POWER OWNED. Mill-powers.	Horse-power, gross.	Horse-power, net. (a)	Steam power in horse-power.	Quantity of water per second.
							Feet.					Cu. feet.
John Hoyt & Co. (b)	A	Paper			Upper canal	Lower canal	21	2	172.72	125		72.26
Langdon Manufacturing Company	B	Cotton	32,256	720	...do	...do	21	8	690.88	500		288.80
Amory Manufacturing Company	C	...do	55,000	1,420	...do	...do	21	16	1,381.76	1,000		577 60
Stark Mills	D	...do	52,000	1,400	...do	...do	21	20	1,727.20	1,250	500	722
Amoskeag Manufacturing Company	E	...do	c171,096	c5,808	...do	...do	21	26	2,245.36	1,625	800	938 60
Amoskeag Pump House	F				Lower canal	River	20	1	86.36	62.5		38
Mechanics' Row	G	Miscellaneous			...do	...do	25	2	172.72	125		60.16
Olzendam's Mill	H	Hosiery			...do	...do	26 }	6	518.16	375		173.28
Amoskeag Electric-Light building					...do	...do	26 }					
Stark Picker House	K				...do	...do	27½	5	431.80	312.5		136.22
Amoskeag Manufacturing Company	L	Cotton, etc			...do	...do	30	56	4,836.16	3,500		1,393.84
Manchester Mills and Print-Works	M	Cotton & woolen	75,000	2,800	...do	...do	30	40	3,454.40	2,500	150	995.60
Namaske Mill (d)	N	Bagging			...do	...do	33	2	172.72	125		45.13
Total			385,352	12,148				184	15,890.24	11,500	1,450	

a The horse-powers in this column are net horse-powers, assuming a mill-power to equal 62½ net horse-power, corresponding to an efficiency of the turbine of about 73 per cent.

b Runs night and day.

c Total operated by the company.

d Owned and operated by the Amoskeag Manufacturing Company.

At the Amoskeag pump-house water is pumped from the lower level to a reservoir in the upper part of the city, to supply hydrant-water to the yards. Mechanics' Row consists of a number of small establishments for wood-working, carpentering, etc., together with a grist-mill taking water from the river by means of a small wing-dam, and using about 30 horse-power, with a fall of 12 feet. On the west side of the river are the paper mills of the P. C. Cheney Company, using 260 horse-power on two wheels, with a fall of 40 feet, and 20 horse-power on another, with a fall of 15 feet, besides two other wheels under 40 feet head in the pulp-mills, giving 440 horse-power. This mill has the right to use water-power only when there is a surplus; at other times steam is used entirely.

It appears from the table that the amount of permanent power held by the various establishments at Manchester is 184 mill-powers, or 15,890 gross horse-power, or about 11,500 net horse-power, being thus considerably greater than that at Lowell or at Lawrence. The normal quantity of water used from the upper canal is 2,599 cubic feet per second, and from the lower canal 2,842 cubic feet per second, so that according to this there must be a waste between the two canals. The mills named in the table can obtain full capacity nearly all the time, but in very dry seasons some steam-power is used by the Amoskeag Company, thus allowing the other mills more water. The total amount of steam-power used, however, either during part of the year or continuously, is very small compared with that used at Lowell, or even at Lawrence. During part of the year there is an excess of power, and regulations have existed since January 1, 1883, similar to those at Lawrence and Lowell, regarding the use of surplus power, which can be used by paying for it at the rate of $5 per mill-power per day. The mills run from 6.30 to 12 a. m., and from 1 to 6.45 p. m., closing at 4 p. m. on Saturdays. Considerable trouble is experienced with ice before the pond freezes over, and sometimes the mills are obliged to stop on account of the filling up of the canals with anchor ice.

The amount of water used by the different mills has hitherto not been determined, as at Lowell and Lawrence, by actual and periodical gaugings. Measurements were made in August, 1879, by Mr. H. F. Mills, chief engineer of the Essex Company, of Lawrence, who, by means of flume measurements in the canals, determined how much water the mills were using, at the same time observing the fall from penstock to wheel-pit, and the height of speed-gate. At the time of my visit to Manchester it was stated that daily observations of the quantity used, by observation of the height of speed-gate and of water in penstock and pit, and comparison with Mr. Mills' measurements, were made only in dry weather, when there was danger of failure of supply. At that time, too, no regulations were in force regarding surplus water, which could be used whenever there was enough of it. Since that time, however, the regulations regarding surplus power have been established, and it may be that systematic observations are or will be enforced.

The drainage area above Manchester is about 2,839 square miles. Systematic and continued gaugings of the flow have not been made, and no data in this respect, further than the figures already adduced, can be given. (*a*)

a I am indebted to Colonel T. L. Livermore, agent, and to Mr. E. A. Hobbs, engineer, of the Amoskeag Company, for information regarding the power at Manchester.

The power at Manchester compares favorably, both as regards amount and facilities for utilization, with any in New England. Few rivers can boast three such powers as those on the Merrimack at Lawrence, Lowell, and Manchester.

THE POWER AT HOOKSETT, NEW HAMPSHIRE.

The next power above Manchester is at the head of the pond, at Hooksett, about 8 miles by the river above the Manchester dam. A canal was over fifty years ago constructed around the Hooksett falls, for purposes of navigation, for, in Tanner's *Description of the Canals and Railroads of the United States,* published in 1840, we find it mentioned, with the statement that it was 825 feet long, with three locks, and a fall of 16 feet. The power was, until 1865, controlled by the Amoskeag Company, but is now owned by the Hooksett Manufacturing Company. The present dam is built of stone, and extends nearly, but not entirely, across the river at the head of the falls, ponding the water for a distance of about 4 miles, with an average width of 300 or 400 feet. It was built in 1841, and is several hundred feet long and perhaps 3 or 4 feet high. It is founded entirely on ledge, and may be raised about a foot by means of flash-boards, which are put on during the summer months. From the dam a canal, about 300 feet long and 20 or 25 feet wide, leads to the cotton-mill of the Hooksett Company, situated on the east bank, the fall used being about 14 feet, and the power about 350 horse-power, which can of course be obtained all the time, there being about the same quantity of water here as at Manchester. No steam-power is used, and there is at all times a great waste of water over and around the dam. It is said that there have been mills at this place for over fifty years, and the dam has been several times rebuilt. The topography is very favorable for the utilization of the power, and a very large amount is still available. The drainage area above the place is about 2,791 square miles, but the power may be estimated from the figures given for Manchester, as there are no important tributaries between the two places. It is probable that for a fall of 14 feet the minimum power is not less than 1,800 gross horse-power continuously, and perhaps more. The pond, however, is probably not large enough to allow of this being concentrated entirely into working hours, though this might be done to some extent. The power is an excellent one and worthy of a place among the great powers of the Merrimack. There is no reason why the full power, of which such a very small fraction is now in use, could not profitably be utilized.

THE POWER AT GARVIN'S FALLS.

About 4 miles above Hooksett and 3 miles below Concord we come to Garvin's falls, the next power, situated just above the mouth of the Soucook river. Many years ago, long before the introduction of railroads into the state, a canal, known as the Bow canal, was built around these falls for purposes of navigation, the remains of which still exist; and the Amoskeag Company, which owns the power, has for some years maintained a dam at the head of the falls, as required by its charter, though no power has been used. Originally a stone dam existed there, but that was carried away some twenty years ago, and the present dam is of wood. It was built in 1879, cost $6,000, is about 550 feet long, and averages 8 feet in height. It backs the water several miles, with a width of some 400 feet, forming a considerable pond. Below the dam, which is founded on ledge, the fall is rapid for some distance, amounting, according to Frank Merrill, civil engineer, of Concord, to 28.4 feet in 1,200 feet. The bed is rocky, and the banks are very favorable for the utilization of the power. The canal extends along the right bank, and is about 2,000 feet long, with several locks at the foot; and although no power has yet been utilized, a pulp-mill is now being erected there, power having been leased from the Amoskeag Company. The old canal is to be used as a race, and the mill located at the foot. The drainage area above these falls measures about 2,412 square miles. The power available is very large, the quantity of water being less than that at Manchester only by that contributed by the Suncook and Soucook rivers and a few brooks. The minimum flow continuously is probably not less than 900 cubic feet per second, which would correspond, on a fall of 28 feet, to a power of nearly 3,000 gross horse-power. The pond would allow of this being increased considerably during working hours, but to what extent I am unable to state. The power is a most excellent one in every respect.

THE POWER AT SEWELL'S FALLS.

The next power above Garvin's falls (except one little rapid not worth considering), and the last on the Merrimack, is at Sewell's falls, about 4 miles above Concord. Around these falls, as around those at Hooksett and at Garvin's falls, a canal was commenced many years ago for purposes of navigation. Its length was a quarter of a mile, and it was completed in 1837; but it is said that difficulty was experienced in the construction of a dam, the bed of the stream being composed of sand and gravel, with no ledge, so that navigation around the falls was never successfully established. The total fall, at lowest water, is 19.1 feet in a distance of 1.75 mile, according to Frank Merrill, civil engineer, of Concord. The greater part of this fall, however, occurs in a distance of a mile. The power is owned by the Concord Land and Water-Power Company, and steps are being taken toward its development. The fall is situated below the mouth of the Contoocook river, and the drainage area above measures about 2,350 square miles. Estimates of the power available are omitted, at the request of the engineer of the

company, on account of the fact that the conditions which will be established regarding flowage, and the arrangements which will be made with the Lake Company regarding quantity of water, are not yet definitely decided upon. Of course, the conditions which may be established here will modify to some extent those existing at the sites lower on the river, so that the figures which have been given in previous pages as to the amount of power available are only to be considered as approximate.

Excellent building materials are found in the vicinity of Concord, the granite having a national reputation. Should this power be developed, one more will be added to the great powers on the Merrimack.

Above Sewell's falls the river has considerable fall, but no good sites for power. The fall between the head of the falls and the junction of the Winnipiseogee and Pemigewasset rivers is, according to the table on page 24, 21 feet. Two miles below Franklin, at Webster Place, a fall commences, which extends for some distance up both rivers, and is extensively utilized on the Winnipiseogee. From Webster Place up to the tail-race of the Winnipiseogee Paper Company, the lowest power on that stream, there is a fall of 14 feet, unutilized, but it is probably not of very much value. From Webster Place to the junction of the two rivers the fall is 10.84 feet at low water.

The following table gives the statistics of power utilized on the Merrimack river. All the powers above Lowell and Lawrence partake equally with those places of the advantage derived from the storage reservoirs on the upper tributaries, though none except Manchester are sufficiently developed to appreciate the benefit. The profile of the river (Fig. 4) shows graphically the abrupt descents which render the river so excellent a source of power:

Table of power utilized on the Merrimack river.

Stream.	Place.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used (gross).	Horse-power used or owned (gross).
						Feet.	
Merrimack river	Lawrence	Massachusetts	Essex	Cotton	3	84	3, 153
Do	do	do	do	Woolen	2	56	298
Do	do	do	do	Cotton and woolen	3	84	5, 583
Do	do	do	do	Flour and grist	2	56	199
Do	do	do	do	Foundery	1	28	28
Do	do	do	do	Leather-board	2	56	191
Do	do	do	do	Braid	1	28	43
Do	do	do	do	Shoddy	1	28	14
Do	do	do	do	Machinery, etc. (*a*)	2	56	93
Do	do	do	do	Paper	4	112	1, 222
Do	do	do	do	Bleachery	1	28	85
Do	do	do	do	Electric light	1	28	....
Do	do	do	do	Lines	1	28	....
Do	Lowell	do	Middlesex	Cotton	7	134½	10, 361
Do	do	do	do	Woolen	1	17	490
Do	do	do	do	Cotton and woolen	1	14	714
Do	do	do	do	Machinery	1	14	280
Do	Manchester	New Hampshire	Hillsborough	Paper	2	6	1, 085
Do	do	do	do	Flour and grist	1	12	*b* 30
Do	do	do	do	Cotton	4	141½	11, 314
Do	do	do	do	Bagging	1	33	173
Do	do	do	do	Cotton and woolen	1	30	3, 454
Do	do	do	do	Pump-house	1	20	86
Do	do	do	do	Miscellaneous			173
Do	do	do	do	Hosiery	1	26	518
Do	do	do	do	Electric light	1	26	
Do	do	do	Merrimack	Cotton	1	14	†350

Total horse-power (gross) utilized in dry seasons, about 39 591.

a Besides these, four machine-shops rent power.

b Net.

THE TRIBUTARIES OF THE MERRIMACK.

In their order, as the Merrimack is ascended, the principal tributaries are the following:

THE POWOW RIVER.

This stream empties from the north, taking its rise in Rockingham county, New Hampshire, in the town of Kingston, and flowing in a southeasterly direction, joining the Merrimack just above Newburyport. Its length is about 10 miles in a straight line, and it drains an area of about 50 square miles. At the head of tide-water are the towns of Amesbury and Saulsbury, where are located the principal powers on the stream. Its drainage basin is low and rather sandy, and the flow of the stream would be exceedingly variable if it were not for the reservoirs, of which there are several, controlled by the Hamilton Woolen Company. The only powers on the stream worth mentioning are those of the above named company, at Amesbury, which has five different dams within a distance of from an eighth to a quarter of a mile, the total fall being nearly 70 feet. The first or upper one is of wood, 26 feet high, the fall utilized being 26 feet, and the power 1,300 horse-power during from three to five months of the year, and sometimes almost nothing. The second dam is 18 feet high, of wood, and only receives what water runs over the one above. It supplies about 25 horse-power when there is a waste over the dam above. The third is 10½ feet high, the fall the same, and the power 75 horse-power during seven or eight months. The fourth is 16 feet high, and the power 150 horse-power, with the same fall. The fifth is 14 feet high, and the fall 14 feet at low water, affording 215 horse-power. All the mills have steam-power, generally enough to run them at full capacity, and some steam is used all the time. About three-eighths of a mile above the upper dam is lake Gardner, with a dam 18 feet high, used only as a storage reservoir and not for power. The gates are shut every night, and the flow of the river thus concentrated, almost at all seasons, into the ten working hours. Only during freshets is there great waste of water.

Several small streams join the Merrimack between Newburyport and Lawrence, but scarcely any are worthy of special mention. One which comes in at Groveland is fed by two ponds, covering, it is said, several hundred acres, so that the stream is excellent for its size, being very constant in flow. Another of the same class enters from the south just below Lawrence, rising in "Great pond" in North Andover, which covers 650 acres at high water, and lies at an elevation of about 75 or 80 feet above the mouth of the stream, which is only 2 miles distant. Almost every foot of this fall is utilized, there being five mills on the stream, with a total fall of 80 feet at low water in the Merrimack, and using together between 150 and 200 horse-power. No water is wasted, and the power of the stream is literally exhausted. Great pond is dammed, and its level can be varied by 11 feet or thereabout, so that it offers considerable storage. Few streams of such small size are better utilized or are more favorable for power than this one.

THE SHAWSHEEN RIVER.

This stream enters the Merrimack from the south, just opposite the city of Lawrence, and drains an area of about 72 square miles. Taking its rise near the town of Lexington, in Middlesex county, it flows in a general northeasterly direction, its length in a straight line being some 18 miles. The principal town on its course is Andover. Its drainage basin comprises principally a hilly and rolling country, like all of eastern Massachusetts, but along the middle part of the course of the stream there are considerable areas of swamp-land, and the stream is very sluggish. In the upper and lower parts its fall is considerable, and its bed and banks are favorable for power, but in the upper part it is too small to be valuable, so that the principal power used is below the town of Ballardvale, or within 5 miles of its mouth. Below this point the fall is rapid, and is all utilized. The flow of the stream is very variable, but no continued gaugings are on record. There is only one artificial reservoir, known as Foster's pond, which is dammed, and the expense of maintaining which is borne by the mills below Ballardvale in proportion to their fall. The exact storage capacity of this pond could not be ascertained, but is very small. Its area is about 40 acres.(a) The river has been sometimes proposed as a source of water-supply for the cities of Boston and Cambridge, but has not yet been so used. The following are the principal powers on the stream:

1. Woolen-mill at Ballardvale, fall 11 feet.
2. Twine-mill of Smith & Dove (upper mill) at Andover, fall 13 feet; 150 horse-power used, but during less than two months of the year; steam sufficient to run all the machinery.
3. Marland woolen-mill, at Andover, fall 12 feet; 150 horse-power during a few months; 90 horse-power steam.
4. Twine-mill of Smith & Dove (lower mill), fall 6 feet.

The stream is sometimes so low that the mills are obliged either to stop or to run entirely by steam.

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a *Report of Massachusetts State Board of Health*, 1873, p. 126.

THE SPICKET RIVER.

This stream empties into the Merrimack at Lawrence, rising in Rockingham county, New Hampshire, and flowing south and southeast into Massachusetts, its length in a straight line being about 15 miles and its drainage area 79 square miles, of which 10 are in Massachusetts. It is not a very good stream for power, its flow being very variable. Several small ponds near the headwaters are dammed and used to regulate the flow, viz: Policy pond, in New Hampshire, covering about 450 acres, and with a range of 8 feet; Island pond, covering about 480 acres, and other smaller ones. In Lawrence there are three mills on the stream, the lowest with a fall of 15 feet, the next with 12 feet, and the third, the Arlington worsted-mill, with 12 feet. The power at the last is stated at 140 horse-power during part of the year. A short distance above, a fall of 39 feet is used, at the Methuen Company's cotton-mill, with 300 horse-power during eight months. In very dry seasons the flow of the stream is very small, and the mills depend upon steam.

BEAVER BROOK.

This stream, which is in all respects similar to the Spicket, rises in Rockingham county, New Hampshire, and flows south, entering the Merrimack opposite Lowell, after draining about 92 square miles. The mill nearest the mouth, that of the Merrimack Manufacturing Company (woolen), uses 175 horse-power during about eight months, with a fall of 18 feet. At times, however, the power is almost nothing, and steam has to be used. There are a few ponds connected with the stream, and used as reservoirs, but their capacity is small. A short distance above the woolen-mill referred to there is a fall, not utilized, said to amount to 12 feet. Above this there are several small mills, as shown by the table on a subsequent page.

THE CONCORD RIVER.

The Concord river is formed in the town of the same name, in Middlesex county, Massachusetts, by the union of its two headwaters, the Sudbury and the Assabet, whence it flows in a nearly northerly direction for a distance of about 12 miles in a straight line, emptying into the Merrimack at Lowell, draining a total area of about 380 square miles, according to my measurements. Its drainage basin is hilly and rolling near the mouth of the stream, and its fall is large, the bed being rocky and the banks high; but from North Billerica to the junction of the two headwaters the stream flows mostly through swamp- and meadow-land, and is exceedingly sluggish, its fall being not over 2 inches per mile, its course very circuitous, and the bed sand and mud. The Assabet, however, drains a more hilly and broken country, and has a rapid fall and high banks, while the Sudbury is for some distance flat, like the Concord. The drainage basin is not well wooded, and the reservoirs used for regulating the flow are not of large capacity, so that the flow of the stream is quite variable, notwithstanding the large areas of meadow-land subject to inundation, and in some cases permanently wet.

The most important power on the Concord is within 2 miles of its mouth, in which distance the fall is not less than 40 feet, over a rocky bed, the fall corresponding to that in the Merrimack, just opposite. The lowest dam is 7 or 8 feet high, and affords a fall of 11 or 12 feet, used on both sides of the river. On the north, the Middlesex woolen-mills use a power of nearly 200 horse-power, taking 167 or 168 cubic feet per second from the river. Full capacity cannot be secured all the year, and steam is in reserve. No water is wasted during nearly ten months of the year, it is said. The mills on the opposite side of the river can only use water when it would otherwise run over the dam. They include the Belvidere Woolen Manufacturing Company's mill, with 75 horse-power during seven months, together with several smaller mills. The power used on this side amounts to about 175 horse power, and can be obtained during six or seven months.

The second dam is a quarter of a mile above, at Massic falls; the fall is 7 or 8 feet, and the power is used by a paper-mill and a woolen-mill.

The third dam is that of the Wamesit Power Company, and is a primitive wooden dam, turning the water into a canal about 2,300 feet long, near the lower end of which are the mills, some discharging the water into Meadow brook, and others into the Concord directly, the fall being 23 or 24 feet. The power is owned by a number of parties, and the estimated flow when the water stands at the top of the dam is 288 cubic feet per second, which is owned as follows:

	Cubic feet per second.
1. L. W. Faulkner & Son (woolen-mill)	25
2. Chase woolen-mill (burned)	48
3. Stirling woolen-mill	36
4. American Bolt Company	36
5. Belvidere Woolen Company	27
6. Wamesit Power Company	68
7. Wood's grist-mill	12
8. Bleachery	36
Total	288

When the flow is less than 288 cubic feet per second, each owner is entitled to a quantity proportional to the amounts given above; thus, the Wamesit Power Company owns $\frac{68}{288}$ of the water flowing at all times. There is no way, however, of dividing the water in these proportions. Full capacity can only be obtained during about eight months, there being sometimes "but little more than enough water for the boilers", all the mills having steam-power in reserve. The Wamesit Power Company has its own wheels and engines, and leases power to a number of small establishments.

The next power on the stream is at North Billerica, where a stone dam 9 feet high affords a fall of 11 feet. Power is used on the west bank by C. P. Talbot & Co.'s mills, the woolen-mill using 400 horse-power during about eight months, and the dye-wood mills 200 horse-power almost all the time. The woolen-mill is run partly by steam (200 horse-power) during about four months. On the east bank, J. R. Faulkner & Co.'s woolen-mill uses 75 horse-power during about six months, using only the surplus water, and running entirely by steam about half the time. On account of the swamps and meadows above here, the freshets are not at all severe, the water seldom rising over 4 feet on the dam, which is 150 feet long.

Above this point the Concord is very circuitous, and is one of the most sluggish of rivers. Between North Billerica and Saxonville, on the Sudbury, a distance along the stream of 29½ miles, there is no power utilized; the course of the stream lies through a very level country, and is bordered by meadow-lands varying in width from a few rods to a mile, covering some 4,000 acres in all, large areas of which are permanently wet. At Saxonville, there are large mills, but they are run mostly by steam since the water of the upper Sudbury has been taken for the supply of Boston. There is no power on the stream between Saxonville and the Boston dam, although a small amount of water is allowed to pass continually. Above the Boston dam the drainage area is about 72 square miles, and there are a few small mills. At the head of one of the branches, in Hopkinton, is a reservoir covering about 576 acres, originally built by the city of Boston as a compensating reservoir, but now owned by private parties and used for power.

The Assabet is essentially different from the Concord and the Sudbury. With higher banks and greater fall, and with no meadows along its course, it is more affected by sudden rains, and rises and falls more quickly. On account of its greater fall it is much more extensively used for power, and a few artificial reservoirs have been built to regulate the flow. The table beyond shows the total fall and power used, and little is to be added. The drainage area is about 175 square miles, and at the American powder-works, not far from the mouth, a power of 200 horse-power is used, with a fall of 11 feet, during about six months, while during the rest of the time the power is small. Most of the mills have steam-power in reserve. Of the reservoirs on the stream we may mention the following: Boon pond, covering 100 acres; Fort Meadow reservoir, built originally by the city of Boston as a compensating reservoir, covering 250 acres, and capable of being drawn down 24 or 25 feet; Gates' pond; Magog pond, on the Nashoba brook, covering 220 acres or more; and other smaller ponds. The privileges are nearly all occupied, no large ones being still unutilized. Both the Sudbury and the Assabet have their sources in Worcester county, whence they flow into Middlesex.

STONY BROOK.

This stream takes its rise in Worcester county, Massachusetts, in Harvard township, and flows northeast into the Merrimack at North Chelmsford, its length in a straight line being about 12 miles, and its drainage area about 35 square miles. It has considerable fall, and is not bordered by meadow-lands, like the Concord, and, considering its size, is quite a good stream for power. It is reservoired to some extent, and regarding the ponds the following approximate data are given: (*a*) Millfield pond, near the mouth, covers about 80 acres; Nabnasset pond covers 98 acres, and can be drawn down 8 feet; Forge pond covers 143 acres, and can also be drawn down 8 feet; Spectacle pond, running into Forge pond, covers 71 acres, with a range of 4 feet. These ponds are controlled by a company representing the mill-owners below. Other ponds covering, in all, several hundred acres, are connected with the stream, but are not dammed. The stream is utilized to a considerable extent, as the table shows. At its mouth is an unutilized privilege with a fall of 6 or 8 feet, subject, however, to backwater. Just above are the mills at North Chelmsford, using a fall of 24 feet, and comprising the Chelmsford foundery, Silver & Gay's machine-shop, and a worsted-mill, the total power used being about 175 horse-power, though at times no power at all is to be had. The mills, as well as those on the upper part of the stream, are generally provided with steam-power.

THE NASHUA RIVER.

The Nashua river is formed by the union of its two branches, the North and the South, the former of which has its sources in the northern part of Worcester county, and flows southeast for a distance of about 18 miles in a straight line, while the latter rises in the central part of the same county and pursues a circuitous course toward the south, east, and north. The former branch drains about 127, the latter about 129, square miles, all comprising a country quite hilly and steep about the upper parts of the streams, while lower down there are considerable areas of low-lying land, and the slopes are very gradual. The topography is favorable to storage, but no

a *Report of Massachusetts State Board of Health*, 1873.

Fig. 12. MAP OF THE DRAINAGE BASIN OF THE NASHUA RIVER.

large reservoirs are in use, the only ones being a few small lakes and ponds near the headwaters of the streams, which, while sufficient to regulate, to a large extent, the flow of the small streams forming their outlets, exercise scarcely any appreciable influence on the main stream. From the junction of the two branches the Nashua pursues a northerly and easterly course, passing into Middlesex county, and then into New Hampshire, joining the Merrimack at Nashua. The length of its course, from the junction to the mouth, is about 24 miles in a straight line, and the total area drained by the stream is about 516 square miles. No important town lies on its course, except Nashua. The drainage basin, below the junction of the two branches, is largely low and level in character, especially that lying along the main stream. The areas drained by the branches which empty from the west are hilly and rolling, resembling the basins of the two headwaters. For a distance of 3 or 4 miles from its mouth the fall of the stream is rapid, the bed rocky, and the banks are high; above that point its fall is less for a distance of from 8 to 10 miles, but the banks are still high enough to confine the river, except in high freshets; but for the remainder of its length, from Groton to the junction of the branches, the stream is very sluggish, its bed and banks are sandy and gravelly, and the latter often subject to overflow, considerable areas of meadow-land which border the stream being inundated at times. The flow is naturally very variable, but is regulated somewhat, though only to a small extent, by the large number of mills on the tributaries of the stream. The rainfall over the basin is about 45 inches, of which 12 fall in spring, 11 in summer, 12 in autumn, and 10 in winter. The stream and its principal branches are easily accessible by rail at all points.

Commencing at the mouth, the first power is at Nashua, close to the Merrimack. A dam about 16 feet high and 134 feet long, with a canal of 1,000 feet, affords a fall of 20 feet at the cotton-mill of the Jackson Company (Indian Head mills). The power used is 1,100 horse-power, which can be obtained during about ten months, steam to the extent of 300 horse-power being in reserve.

About a mile above is the cotton-mill of the Nashua Manufacturing Company, where, with a dam 16 feet high and a canal 3 miles long, a fall of 36 feet is obtained, with 1,200 horse-power in use. Full capacity can generally be obtained for ten or eleven months, but a large amount of steam-power is in use.

The drainage area being 516 square miles, I should estimate the flow of the stream at this point about as follows:

Estimate of flow of Nashua river at Nashua.

State of flow (see pages 8–10).	Flow per second.	Horse-power available (gross) continuously.		
	Cubic feet.	1 *foot fall.*	20 *feet fall.*	36 *feet fall.*
Minimum	85	9.6	192	346
Minimum low season	115	13.1	262	472
Maximum, with storage	400	45.4	908	1,634
Low season, dry years	135	15.3	306	551

Five miles above Nashua, at Runnell's bridge, is an unimproved privilege, said to have a fall of 8 feet. Four miles above, at Pepperell, are the mills of the Fairchild Paper Company. A fall of 13 feet is used and 500 horse-power obtained during nine months at the upper mill, and 6½ feet with about 300 horse-power at the lower mill. A paper-mill at Groton completes the list of mills on the Nashua. Above this point the stream is sluggish, and flows through meadow-lands, up to the junction of the two branches.

Of the tributaries of the Nashua, the only ones worth mentioning below the junction of the branches are Nissittissit and Squannacook rivers, both of which enter from the west and are similar in character, rising in New Hampshire, at a considerable elevation, and draining a hilly country, with considerable fall. They seem to be very good streams for power, except that their flow is quite variable; and they are utilized by a number of mills of various kinds. At Shirley a small stream enters, which is the outlet of several ponds, covering, in all, several hundred acres, and running several cotton-mills, as well as mills of other kinds, but steam is used during part of the year.

The North branch of the Nashua has a rapid fall, is an excellent stream for power, and is well utilized. Several reservoirs on the headwaters serve to regulate the flow to some extent, and the large number of mill-ponds have a similar effect; but as no large reservoirs exist, the flow is still quite variable. Wachusett pond, on one of the branches, covers several hundred acres, and may be drawn down 16 feet; Meeting-house pond, tributary to it, covers about 172 acres, with a range of 10 feet; a third reservoir, in Gardner, can be drawn down 13 feet, but its area could not be ascertained; a fourth, in Ashburnham, covers several hundred acres, and can be drawn down about 17 feet. There are a large number of mills on the stream, as the table of utilized power shows, but steam-power is generally in reserve. Four unutilized privileges are said to exist on the stream. The first is near the mouth, and is improved, the mill being formerly occupied for the manufacture of shoe-shanks; the second is a little above, and the fall is said to be about 9 feet; the third is a short distance below Fitchburg, and the fall is said to be 22 feet; immediately above is a scythe-shop, not now running, with a fall of 14 feet. Above this point the fall of the stream and of its tributaries is very rapid, and is utilized by many mills. The tributaries, too, are rapid streams, generally almost completely utilized, though there are some unutilized sites. One little stream running through Leominster runs no fewer than ten mills, with over 130 feet fall.

The South branch of the Nashua resembles the north, and, like it, is well utilized. At Clinton the Lancaster gingham-mills use a fall of 27 feet and 700 horse-power, but only during two or three months. Sufficient steam-power is at hand to run the entire machinery. The Stillwater and Quinepoxet rivers, which form the stream, are very rapid, and in all respects favorable for power, except that their flow is very variable. Some small reservoirs serve, however, to regulate their flow to some extent, two which empty near the mouth of the Stillwater covering about 370 acres. Near Clinton several ponds, covering 235 acres and capable of being drawn down some 17 feet, serve to run several large mills.

PENNICHUCK BROOK.

This small stream empties into the Merrimack about 2 miles above the Nashua. It has considerable fall, and is utilized by a few saw-mills and by the water-works supplying Nashua. The water-works have two dams, with falls of 17 and 15 feet, respectively, and water-power is used to pump the water from the brook to a height of 132 feet, the average quantity pumped per day being 1,000,000 gallons.

THE SOUHEGAN RIVER.

The Souhegan has its sources in Worcester county, Massachusetts, and flows first in a northeasterly direction for 12 or 15 miles into Hillsborough county, New Hampshire, then turning and flowing east for about an equal distance, emptying into the Merrimack at Merrimack station, about 8 miles above Nashua. The principal towns on the course of the stream are Greenville, Wilton, and Milford. The area drained is about 224 square miles, comprising a very hilly country. The fall of the stream is very large, though no data regarding it are at hand, but its total descent from the Massachusetts line is not less than 700 feet. The bed and banks are rocky, with few low grounds subject to overflow, and the stream is quick to rise and fall. Its flow is said, in fact, to be extremely variable, and, as there are no lakes and no artificial reservoirs to regulate it, the statement is probably correct. The mills on the stream are quite numerous, but a large amount of fall is still unutilized, some sites being not very accessible, though a railroad touches the river at the mouth and at Greenville, and follows it from Milford to Wilton. The following data are very incomplete, but are all that could be obtained with the time at disposal:

At the mouth of the stream there is a fall of 25 or 30 feet over a ledge of rock, with a wooden dam about 10 feet high. The power is used by three woolen-mills and a cabinet-shop, with perhaps 100 or 125 horse-power in all; but, although the power is an excellent one, it is very badly utilized, and could be made much more valuable than it is at present. Probably the minimum power would not be less than about 3½ horse-power per foot during twenty-four hours, while, during the low season of dry years there would perhaps be 4½ or 5 horse-power continuously. The pond is said to be large enough to store the low-water flow during the night. The local conditions are favorable for the utilization of the power, and, properly developed, this would be one of the best of the small powers in the vicinity. It is within a quarter of a mile of the Concord railroad.

A short distance above is a fall known as Parker's, not improved, though said to be a fine site. The fall is said to be 23 feet. Then comes Atherton's falls, not improved, the fall being stated at 28 feet; then Nichol's falls, 10 feet; Wilkin's falls, 8 feet; Fuller's falls, 12 feet; and Field's falls, all in the town of Merrimack. (*a*)

About 3 miles above this is a small mill, beyond which there is nothing below Milford, 8 or 10 miles from the mouth. This town is quite a manufacturing center, and a number of dams cross the stream; but no details regarding the power are at hand, except the statistics given beyond. Above Milford there are several mills, and a number of sites that might be utilized. Several mills, however, have recently been built, and all the good sites will probably be soon occupied.

The Souhegan may probably be said to possess a greater proportion of unutilized water-power than any stream in the vicinity, and its resources deserve attention. Its fall is very large, and, although its flow is very variable, a systematic utilization of the power would do much to remedy this objection.

COHASS BROOK.

This is a small stream, entering the Merrimack from the east just below Manchester. It takes its rise in Massabesic lake, which lies about 4 miles east of the city, and covers about 2,400 acres, its drainage area being about 44 square miles. From this lake, which is situated at an elevation above tide of about 256 feet, Cohass brook pursues a course measuring about 5 miles in a straight line, in which distance it descends not less than 140 feet, draining a total area of about 68 square miles. Its basin is hilly, comprising little flat or meadow land, except in a few cases, below the lake, where the stream is bordered by such lands. Lake Massabesic is used as a source of water-supply for the city of Manchester, the stream being dammed a short distance below its outlet, and the water being pumped up by water-power. The dam is of stone, 100 feet long and 24 feet high, and was built in 1873. A canal and penstock 2,070 feet long afford a fall of 43 feet, and a power of 120 horse-power is used during twelve hours every day, there being seldom a lack of water. Twelve hundred thousand gallons per day are pumped to a height of 113 feet. On account of the large size of the pond no water is wasted in dry seasons, and the range of water in the pond is but 5 feet.

a *Report of the Commissioners on the Preliminary Examination of the Water-power of New Hampshire* (1870), p. 47.

Below this dam a meadow borders the stream for some distance, below which is an unutilized fall of perhaps 5 or 6 feet, once used. Then comes a saw-mill, which is at present not in operation, with a fall of 12 feet or so, and then a second fall of 8 or 10 feet, not used. At the mouth of the stream are the Derry woolen-mills, there being three dams, with falls of 14, 12, and 12 feet, respectively. About 90 horse-power are used on each fall, and full capacity is secured nearly all the time, no steam being in use. The flow of the stream is quite regular, even more so than before the water-works were built, and freshets are unknown.

Although the above are all the falls that could be learned of, there must be more fall on the stream still unutilized, in order to make up the total fall of about 140 feet, above mentioned.

THE PISCATAQUOG RIVER.

This stream has two branches, which unite in the town of Goffstown, near Parker's station, whence the stream flows in an easterly and southerly direction for a distance of about 8 miles, emptying into the Merrimack just opposite Manchester, and draining a total area of about 214 square miles. The North branch takes its rise in the town of Deering, and pursues a circuitous course eastward, draining about 77 square miles, while the South branch rises in Francestown, and drains about 100 square miles. The drainage area is hilly, and the fall of the stream is great, though not so large as that of the western tributaries of the Merrimack between this point and the state line. The bed and banks are generally rocky where the falls occur, but are often light and sandy in the intervals. The flow is quite variable, there being no lakes or artificial reservoirs of importance. Mount William pond, in Weare; Gregg's pond, in Deering; and Haunted pond, in Francestown, cover respectively about 125, 250, and 190 acres, and are the largest in the basin. Facilities for storage, however, are said to exist, and have been talked of in connection with the water-supply of Manchester.

Near the mouth of the stream is a shuttle factory, with a fall of 10½ feet, and about 60 horse-power during nine months. Two miles above is an unutilized fall known as Kelly's falls, where the fall is small, but where it is said that a dam 18 feet high could be built. At Goffstown Centre a pulp-mill uses a fall of 13 feet and 167 horse-power during about nine months, no steam being used. Between this mill and Goffstown West Village there is considerable unutilized fall. At the latter place a sash-and-blind mill uses 13 feet, and above that point there are various small mills on both branches, and several small unutilized privileges. That the fall of the stream is large is shown by the fact that its elevation at Parker's station is about 299 feet, while at its mouth it is about 121 feet, so that the slope between these points is at the rate of not less than 12 or 15 feet per mile, while above Parker's station the slope is even more rapid than below. The total fall utilized within the distance referred to being about 50 feet, there is an unutilized fall on this stream, below the junction of the two branches, of about 128 feet. No gaugings of the flow are on record, but it has been estimated at about 45 cubic feet per second, on the average, during the summer months. Its minimum flow is probably not over half this quantity. On the upper branches of the stream there is no doubt a large amount of power entirely unused.

THE SUNCOOK RIVER.

This stream, the next important tributary of the Merrimack, takes its rise at the foot of Gunstock mountain, in Belknap county, whence it pursues a course toward the south and west, entering the Merrimack in Merrimack county, about 6 miles below Concord and 2 miles above Hooksett. Its length measured in a straight line is about 27 miles, and its drainage area measures about 264 square miles, its largest tributary being the Little Suncook, which drains 44 square miles. The principal towns on the stream are Suncook, at the mouth, and Pittsfield. The drainage basin is hilly and broken, more so than that of the streams south; the bed and banks of the stream are often rock, and there are no swamps or meadow-lands of importance subject to inundation. The fall of the stream is large. Lougee pond, near its head, lies at an elevation above the sea of 622 feet, while the height of its mouth is about 198 feet, so that the total fall of the stream between these points, or about 22 miles in a straight line, is about 424 feet. Allowing for the windings of the stream, its declivity is probably not less than 12 feet to the mile.

The following table gives some additional elevations:

Declivity of the Suncook river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	198			
			12±	138	11.5±
Mouth of Little Suncook	12±	336			
			8±	135	16.9±
Pittsfield, above dam	20±	471			
			12±	151	12.6±
Lougee pond	32±	622			

Of the total fall mentioned, only about 350 feet are utilized, so that some fall is still available. The flow of the stream is regulated to some extent by a number of ponds near the headwaters of the stream, but near the mouth their effect is small. Of these ponds we may mention the following, with their areas as given by the agent of the Pittsfield mills, Mr. G. E. Kent: Lougee pond, 627 acres, from which 5½ feet can be drawn; Upper Suncook pond, 380 acres, and Lower Suncook pond, 294 acres, from both of which 8 feet may be drawn; Place's pond, 300 acres, from which 11 feet may be drawn; Half Moon pond, 361 acres, and Brindle pond, 250 acres, not dammed; Hill's pond, 100 acres, a range of 2 feet being controlled; together with eight other ponds not dammed, with a total area of 711 acres—making in all, above Pittsfield, fifteen ponds, with a combined area of 3,023 acres. Besides these, the manufacturing companies at Suncook control two ponds, both on the Little Suncook, viz: Suncook pond, 500 acres, from which 4 feet may be drawn, and Pleasant pond, 500 acres, from which 6 feet may be drawn. Notwithstanding these regulators, the flow of the stream is quite variable, though no trouble is experienced with freshets. A railroad follows the stream as far as Pittsfield, thus rendering every important point easily accessible. The important powers on the stream are the following:

Within a mile of the mouth the fall is about 80 feet, used by three cotton-mills. At the lowest, that of the China Manufacturing Company, the fall is 35 feet, and about 1,000 (?) horse-power are used during about nine months. The dam is about 25 feet high, and the canal 1,000 feet long. Steam is in reserve to the extent of 1,000 horse-power. At the next mill, the Pembroke, a stone dam 17 feet high affords a fall of 17 feet, with 350 (?) horse-power used almost all the time, steam being only used to the extent of 75 horse-power. At the third mill, that of the Webster Manufacturing Company, a wooden dam 7 feet high, with a canal of 1,200 feet, affords a fall of 27 feet and 500 (?) horse-power, considerable steam being used all the time. At these mills there is no waste of water in a dry time.

The next mill above is a saw- and grist-mill, using but a small amount of power. The pond is used principally to regulate the flow, the dam being provided with gates which are shut every night and opened every morning. The flow at this point, which is the same as that at the mills below, might be estimated about as follows, the drainage area being about 264 square miles: Minimum, 50 cubic feet per second, or about 5.7 horse-power per foot continuously; minimum low season, 62 cubic feet per second, or about 7.1 horse-power per foot; low season, dry years, 71 cubic feet per second, or 8.1 horse-power per foot; and maximum with storage, 180 cubic feet per second, or about 20 horse-power per foot.

At Backstreet there are two dams, with a total fall of about 22 feet. At Short falls, and at various points above, there are small mills, using only small amounts of power. At Pittsfield the Pittsfield cotton-mills use a fall of 18 feet, and obtain 200 horse-power all the time, by saving the water at night during six months of the year. Between the mouth of the Little Suncook and this place there are numerous unimproved sites. Above Pittsfield there is a dam used for regulating, being shut every night, and still farther up are the ponds which have been named.

On the Little Suncook there are various small mills, supplied with very constant power. Both streams may be called excellent streams for power, and considerable additional power will no doubt some time be utilized on them. Suncook pond, at the head of the Little Suncook, has an elevation of 512 feet, while the mouth of the stream is at an elevation of 336 feet. The total fall of the Little Suncook is, therefore, 176 feet, or about 35 feet per mile.

THE SOUCOOK RIVER.

This stream, which rises in the southern part of Belknap county, pursues a southerly course almost parallel to that of the Suncook, emptying into the Merrimack about 2 miles above the mouth of the latter. Its length, in a straight line, is about 20 miles, and it drains an area of about 90 square miles. Its power seems of little importance, for not only is very little used, but the stream is said to be sluggish and unfit for power in its lower parts, while above it is too small, its flow being also very variable. It may, therefore, be dismissed without further description.

THE CONTOOCOOK RIVER.

The Contoocook, the largest tributary of the Merrimack, takes its rise in the southeastern corner of Cheshire county, very near the Massachusetts line, its sources being a number of ponds in the towns of Jaffrey and Rindge. For about 25 miles in a direct distance the course of the stream is a few degrees east of north, the river passing into Hillsborough and Merrimack counties; for the remainder of its length, or about 20 miles in a straight line, its course is northeast, till it joins the Merrimack at Fisherville, about 6 miles north of the city of Concord. Its length, measured along its course, is over 50 miles, and its total drainage area measures about 766 square miles. The principal towns on the stream are Peterborough, Bennington, Antrim, Hillsborough, Henniker, and Hopkinton. The fall of the stream is large, as the following table shows. Rising at an elevation of between 1,100 and 1,200 feet above the sea, it falls, in its course of about 55 miles, to an elevation of 249 feet, or an average of about 15.7 feet per mile. Its declivity is not gradual, however, but is broken by a number of abrupt falls, rendering a large amount of power available. The topography of the drainage area is rather peculiar. Separated on the south by a

Fig. 13. MAP OF THE DRAINAGE BASIN OF THE CONTOOCOOK RIVER.

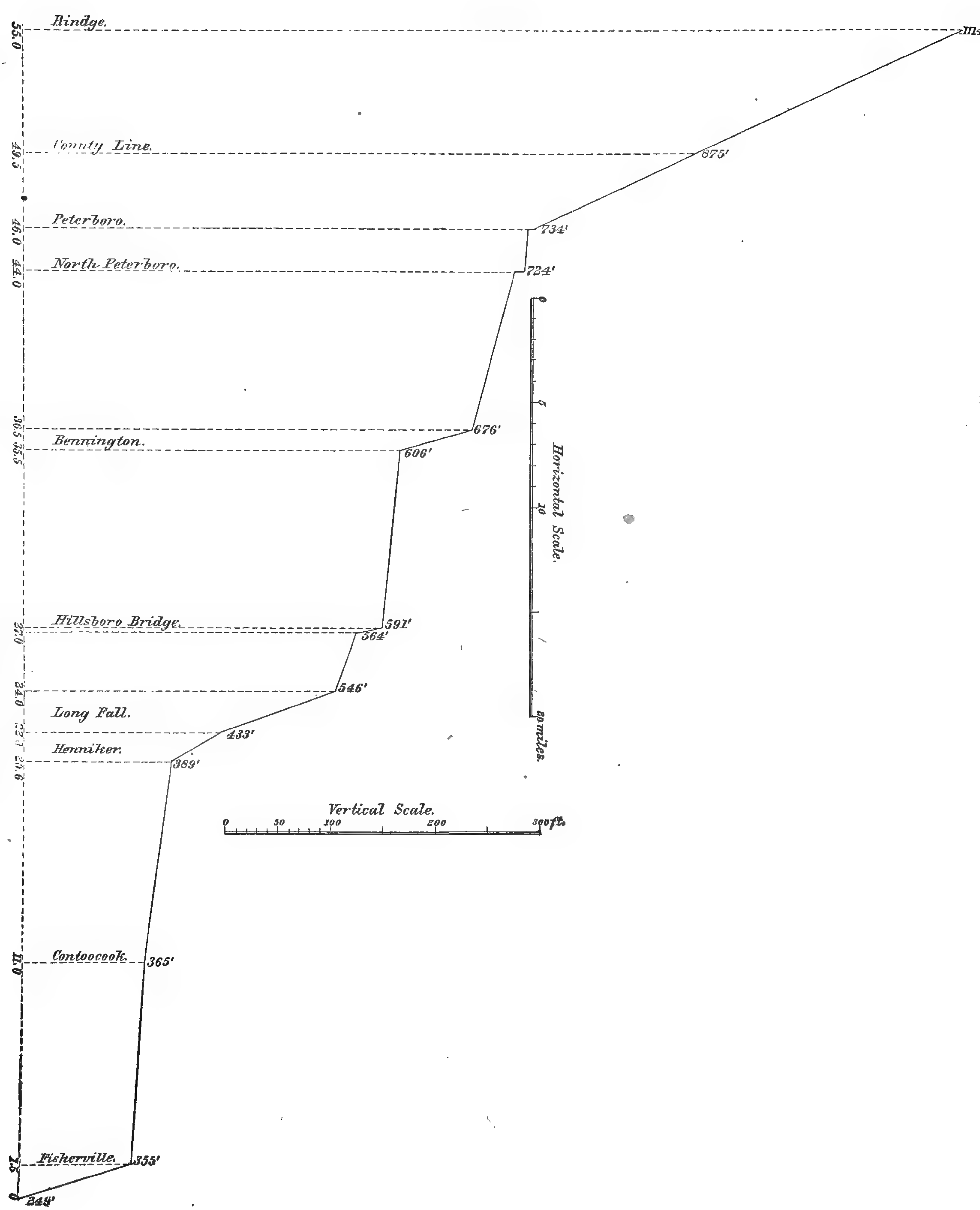

Fig. 14. PROFILE OF THE CONTOOCOOK RIVER.

range of hills from the sources of the tributaries of the Connecticut, it is bounded on the east by a range of high and irregular hills which separate it from the main valley of the Merrimack, and which increase in height toward the south. From these hills the valley spreads out toward the west, first falling suddenly, then rising gradually to the water-shed between the Contoocook and the Connecticut. It is in the extreme eastern part of the basin that the course of the stream lies, flowing at the very base of the hills separating it from the Merrimack. From the east, therefore, the stream receives no tributaries of importance, while from the west and northwest it receives important affluents. Flowing, then, in a direction almost contrary to that of the stream it seeks to join, the Contoocook finally cuts through, near Henniker, the hills separating the two, and then flows more directly toward it.

Declivity of the Contoocook river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	249±			
One and one-half miles above mouth	1.5	355	1.5	106	71.0
Just above Contoocookville	11.0	365	9.5	10	1.0
Just below Henniker	20.6	389	9.6	24	2.5
Foot of Long fall	22.0	433	1.4	44	31.4
Head of Long fall	24.0	546	2.0	113	56.5
Foot of falls at Hillsborough bridge	26.8	564	2.8	18	6.4
Head of falls at Hillsborough bridge	27.0	591	0.2	27	135.0
Foot of falls at Bennington	35.5	606	8.5	15	1.8
Head of falls at Bennington	36.5	676	1.0	70	70.0
Foot of falls at North Peterborough	44.0	714	7.5	38	5.1
Head of falls at North Peterborough	44.0	724	0	10	....
Foot of falls at Peterborough	46.0	727	2.0	3	1.5
Head of falls at Peterborough	46.0	734	0	7	....
Hillsborough county-line	49.5	875±	3.5	141	40.3
Three Ponds, in Rindge	55.0	1,114	5.5	239	43.4

The bed and banks of the Contoocook are in every way favorable for power. The former is generally of rock or gravel, and no difficulty is found in building dams at the places where power is available. The banks are generally high enough to confine the stream, there being few low grounds subject to overflow except along the lower part of the stream, below West Hopkinton. The flow of the stream is quite variable, there being no large reservoirs by which it is regulated. A few small ponds and reservoirs near the headwaters and on the tributaries are utilized by the mill-owners for purposes of storage, but they exercise little effect on the main stream. The freshets, however, though quite heavy, cause little or no trouble, on account of the large fall of the stream. The basin is tolerably well wooded. No gaugings of the flow are on record, but some estimates are presented below. The rainfall over the basin averages about 44 inches, of which 11 fall in spring and in summer, 13 in autumn, and 9 in winter; a distribution favorable for constant flow. A railroad follows the river for almost its entire length, rendering every point easily accessible.

The first power on the river, as it is ascended, is at Fisherville, where the fall amounts to over 100 feet in a distance of 1½ mile. Within this distance there are a number of dams and mills of various kinds, but the power is not economically utilized, and a considerable amount is wasted. The upper dam is 1½ mile above the mouth of the stream, and is of wood, 10 feet high, ponding the water for about 6 miles. It turns the water into a partly natural channel between the shore and an island, and a fall of 7½ feet is used by a saw-mill, by means of a dam across this channel, the water being discharged into the channel below the dam. Just below, a fall of 20 feet is available, using this same water, but no power is yet used here.

The next dam below is the Penacook dam, 1 mile below, the total fall between it and the dam above being about 30 feet. This dam is about 200 feet long and 12 or 13 feet high, making a pond covering at least 520,000 square feet. A canal about 1,100 feet long affords a fall of from 12 to 15 feet, used on the right bank by the following mills: Penacook cotton-mill, 15 feet fall and about 350 horse-power; C. H. Amsden's furniture factory, with 12 feet fall and about 115 horse-power; and a table factory, with about 12 feet fall and 25 horse-power. The power is owned by the Contoocook Manufacturing Company, and power, etc., leased by those using it. Full capacity can generally be obtained by all these mills, but in dry weather there is no waste at night. The water from the last two mills passes into the pond below, the next or third dam being of wood, about 225 feet long and 8 or 9 feet high, supplying the cotton-mill of the Contoocook Manufacturing Company, on the left bank, with a fall of 15 feet and about 150 horse-power, which can always be obtained. Part of the water from the Penacook mill passes into the pond of this

dam; the rest supplies the Concord Axle Company, which uses a fall of about 7½ feet and about 60 horse-power. Between this point and the next or lowest dam some fall is not utilized. The last dam is a primitive affair, making no pond and turning the water into races on both sides of the river. On the south or right bank a canal about 400 feet long supplies C. M. & A. W. Rolfe's sash, door, and blind factory with a fall of 9 feet and about 30 horse-power, followed by Blanchard's Excelsior mill, with a fall of 17 feet, now, however, not in operation. On the north or left bank are Harris' woolen-mill, with a fall of 16 feet and about 35 horse-power, and Stratton, Merrill & Co.'s saw-mill and flour-mill, with about 90 horse-power at the latter, the fall being about 20 feet. The latter firm also leases some power to an ax-handle factory, a granite-polishing shop, and saw-works. A large amount of fall is wasted here in the races. Between the lowest mills and the river there is some fall, amounting, at low water, to 4 or 5 feet, but in high water this disappears.

It will be evident that the power at Fisherville, naturally a very fine one, is wastefully utilized and in part yet unimproved. Taking the drainage area above the uppermost dam as 760 square miles, we may estimate the available power about as follows:

Estimate of power of the Contoocook river at Fisherville.

State of flow (see pages 8-10).	Flow per second.	Horse-power available (gross) continuously.		Flow during twelve hours.	Horse-power available (gross) during twelve hours.	
	Cubic feet.	*1 foot fall.*	*100 feet fall.*	*Cu. ft.*	*1 foot fall.*	*100 feet fall.*
Minimum	150	17.0	1,700	300	34.0	3,400
Minimum low season	190	21.6	2,160	380	43.2	4,320
Maximum, with storage	450	51.1	5,110	665	75.6	7,560
Low season, dry years	220	25.0	2,500	435	50.0	5,000

According to a report by John R. Freeman, hydraulic engineer, of Lawrence, Massachusetts, the storage on the upper pond is probably sufficient to store a quantity of water which would give a flow of 215 cubic feet per second during twelve hours, thereby doubling the low-season flow during working hours. Mr. Freeman made a gauging when the river was said to be in its ordinary summer condition, and found the flow without storage to be 269 cubic feet per second. The large power at this place is thus far from completely utilized, and there is opportunity for great development. Between Fisherville and West Hopkinton the river is bordered by lowlands, while above the latter place the banks are generally high.

The next power above Fisherville is 12 miles above the upper dam, by the river, at Contoocookville. At Blackwater falls, 6 miles above the upper dam, there is a small fall, but it is destroyed by the flash-boards below, and is of no value. At Contoocookville a fall of 7 or 8 feet is used for a saw- and grist-mill and a machine-shop, with a small amount of power and a very leaky dam, though considerable power is available. At West Hopkinton, about 3½ miles above, a fall of 7 or 8 feet is used. Between this and the next power, at Henniker, there is some fall not used. At Henniker there are two dams. The lower one affords a fall of 12 feet at a small mill, and the upper one a fall of 8 feet. At West Henniker a fall of 12 feet is used at a paper-mill, using 100 horse-power, which can be obtained during about eleven months. Above the pond of this mill, which is about a quarter of a mile long, the fall is very rapid for 2 miles, amounting to 113 feet in that distance, the river winding through a narrow valley, with a rocky bed and high banks. A large portion of this fall could probably be rendered available, but none is yet utilized. The quantity of water is the same as at Hillsborough, and from the table below the power available can be seen. At Hillsborough there are two dams. The lower one is about 12 feet high, and supplies a canal on each side of the river, power being used on the south side for two knitting-mills, with about 75 horse-power, a needle-shop, and a grist-mill, with perhaps 40 horse-power; and on the north side for a saw-mill with 75 horse-power, and a silk factory with 8 horse-power. The fall is from 12 to 16 feet. In dry weather no water is wasted at night, except what leaks through the dam. The upper dam is about 11 feet high and ponds the water about 5 miles. The fall is 14 feet, used by the Hillsborough woolen-mill, with 80 or 90 horse-power. Half the river is owned on the other side, but is not used, except that gates are opened there to let water pass into the lower pond when it does not flow over the dam.

The drainage area above Hillsborough is about 359 square miles, and the power may be estimated about as follows:

Estimate of power at Hillsborough Bridge.

State of flow (see pages 8-10).	Flow per second.	Horse-power available (gross) continuously.			
	Cubic feet.	*1 foot fall.*	*12 feet fall.*	*14 feet fall.*	*113 feet fall.*
Minimum	60	6.8	82	95	768
Minimum low season	72	8.2	98	115	927
Maximum with storage	250	28.4	341	398	3,209
Low season, dry years	82	9.3	112	130	1,051

As already stated, the dry-weather flow may all be concentrated into twelve hours, and the power thus doubled.

The next power above Hillsborough bridge is at Bennington, about 9 miles distant. At this place the fall is 70 feet in about 2 miles, and is utilized at five dams. The uppermost dam, which is 7 or 8 feet high, is a mile above the station, and was formerly utilized by a powder-mill, but is now used only as a regulator. Below it is a dam about 12 feet high, affording a fall of 12 feet at a knife factory. Next below are a grist- and saw-mill and a second knife factory, the former with a fall of 12 feet, the latter with one of 7 feet, from different dams. The fifth dam supplies a paper-mill, with a fall of 18 feet, and about 120 horse-power, during part of the year.

The power at Bennington is badly utilized, and might be made much more valuable than it now is. The amount of power may be estimated as follows, the drainage area being about 194 square miles:

Estimate of power at Bennington.

State of flow (see pages 8–10).	Flow per second.	Horse-power available (gross) continuously.	
	Cubic feet.	1 *foot fall.*	70 *feet fall.*
Minimum	30	3.4	238
Minimum low season	36	4.1	287
Maximum, with storage	150	17.0	1,190
Low season, dry years	42	4.8	336

The ponds are all small, excepting the upper two, but these are large enough to allow of the power being greatly increased, and probably doubled, during working hours.

The next power above Bennington is 2 miles below Peterborough, where a fall of 10 feet is utilized. At Peterborough a grist-mill uses 7 feet, and above this place are various small mills and several unutilized privileges. Half a mile above the town is a fall of 6 or 7 feet, once utilized; then just above is the "Kimball" privilege, also unutilized, said to have a fall of 10 feet; and 2½ miles above the town is a third unutilized site, the fall being considerable for a distance of a mile or so. The upper parts of the stream are well utilized, and, on account of the ponds on the headwaters, the power is more constant than lower down. Few details could be learned regarding these ponds, except that some are dammed and used for regulating. Their effect is only felt appreciably on the upper parts of the river.

Of the tributaries of the Contoocook, the first to be mentioned is the Blackwater river, which takes its rise in Pleasant pond, in the northern part of Merrimack county, and pursues a southerly and easterly course, draining about 132 square miles, and joining the Contoocook about 6¼ miles above its mouth. The privileges on the stream were named to me as follows, by those acquainted with it, in their order as one ascends: 1. An old privilege, not used, with 10 feet; 2. Jackman's mills, where the total fall is some 30 feet, 10 feet being used at present by a saw-mill; 3. Dodge's mills, a saw-mill, with 12 feet; 4. Swett's mills, a grist-mill, with 15 or 20 feet used and considerably more available; 5. Burbank's saw-mill, 10 feet. Above this are numerous small mills not worth naming. Pleasant pond is dammed to a height of about 6 feet, and used by a mill below. The stream is quite a good one for power, but its flow is very variable, and the mills sometimes have to stop.

The next tributary is Warner river, a stream very similar to the Blackwater. It rises in the western part of the county, and pursues a course a little south of east, joining the Contoocook just below Contoocookville. The powers are as follows:

1. At Davisville there is a fall of 42 feet in a quarter of a mile, with a dam of 8 or 10 feet, of which about 12 feet are used for a paper-mill, with a power of 60 horse-power continuously during about nine months, and 12 feet for a machine-shop, with about 30 horse-power. Below this, a fall of 18 feet is not used. This site is the best on the river.
2. At Warner village, a grist-mill uses 6 or 7 feet.
3. At Waterloo a fall of 15 or 20 feet is used.
4. At Roby's corner a fall of 8 feet is not used.

Above this are various small mills, and other sites not used. Several ponds feed the stream, viz: Long pond, in Webster, about 500 acres, dammed about 4 feet, and used for regulating; Bradford pond, covering 500 acres, not dammed; Long pond, in Sutton, covering 200 acres, and dammed. The stream offers considerable facilities for the development of small powers, but its flow, like that of the Blackwater, is very variable.

The North branch of the Contoocook, which joins the main stream just above Hillsborough bridge, runs a few small mills, but no details are at hand. Several ponds flow into this stream, the principal ones being Long pond, which covers about 450 acres, and can be drawn down about 5 feet; Island pond, covering about 380 acres, but said to be not regulated; Loon pond and Contention pond, each covering about 200 acres, and not regulated. The stream has a large fall, descending over 432 feet from source to mouth.

Great brook, which enters the river in Antrim, from the west, is the outlet of Gregg's pond, and falls 464 feet from the pond to the river, in a distance of only about 3 miles, running a number of mills. The power is small, but quite constant.

The only remaining tributary worth naming is Nubanusit creek, which enters from the west in Peterborough, draining about 56 square miles. It has a very rapid fall and runs a number of mills. Near the mouth is the Phenix factory, with a fall of 25 feet, and 136 horse-power during part of the year, and just above it is a pulp-mill with 26 feet, and about 200 horse-power. Within a mile of its mouth its fall is not less than 100 feet, and it extends some distance farther up the stream with almost the same slope. A fall of 14 feet, unutilized, is said to exist below the lower mill of the Union Manufacturing Company, and another, of 52 feet, above their upper mill. Above this point there are extensive meadows, which, it is said, could easily be flooded, and a reservoir formed sufficient to increase very greatly the power below; and other similar meadows exist farther up. The upper parts of the stream are well utilized, but some unutilized sites still exist—one, with 14 feet fall, just above the lower meadow, and others still above. The stream is fed by some ponds, viz, Thorndike pond, covering, it is said, 450 acres, and capable of being drawn down 6 feet, entering the main stream just above the unutilized fall of 52 feet; Spoonwood pond, the head of the stream, covering 160 acres, and capable of being drawn down 10 feet; Long pond, 800 (?) acres, with a range of 12 feet; Twichell pond, 120 acres, with a range of 4 feet; Phenix reservoir, covering several hundred acres, with a range of 6 or 7 feet, and lying at an elevation of 1,218 feet. The power of this little stream, which falls over 500 feet from Harrisville to its mouth, is excellent, though small. The mill-ponds on the lower part are small, but those above suffice to store the water at night, in dry seasons, rendering it possible to control the flow. The stream could no doubt be further improved in this direction, and there is a large amount of fall upon it still unutilized.

THE WINNIPISEOGEE RIVER.

This river, which has already been referred to as one of the headwaters of the Merrimack, is a most remarkable stream. Lake Winnipiseogee, of which it is the outlet, lies in Belknap and Carroll counties, and covers, when full, an area of 71¾ square miles, including Long bay, receiving, in addition, through its tributaries, the waters of various smaller lakes and ponds, aggregating about 11 square miles in area. From the lake the Winnipiseogee river passes first by the town of Lake Village into Round bay, which covers about 0.5 square mile, and then flows by the town of Laconia into Great bay, covering 7.33 square miles; thence it continues its course toward the southeast, widening into numerous bays, until at last it joins the Pemigewasset at Franklin, to form the Merrimack. The length of its course, in a straight line from Lake Village to Franklin, is about 12 miles, and its total drainage area measures not less than 480 square miles. Further data regarding the area drained above other points are given in the table on a subsequent page. Within this short course of 12 miles the stream descends not less than 225 feet. The following table shows its declivity more in detail, and from it Fig. 16 has been constructed. The figures are only approximate, but are not far from the truth:

Declivity of the Winnipiseogee river.

Place.	Distance from mouth.	Elevation above sea.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Lake Winnipiseogee	13.65	496–502.0	....	10.0±	
Lake Village, below dam	13.65	490.0	0.06	2.0	
Round bay, head	13.59	488.0	1.25	....	
Round bay, foot	12.34	488.0	0.42	0.5	
Laconia, above dam	11.92	487.5	....	8.0	
Laconia, below dam	11.92	479.5	0.75	1.5	
Great bay, head	11.17	478.0	3.86	....	4.88
Sanbornton bay, foot	7.31	478.0	0.62	1.5	
Union bridge, above dam	6.69	476.0	....	9.5	
Union bridge, below dam	6.69	466.5	0.08	6.0	
Little bay, head	6.61	460.5	1.35	....	
Little bay, foot	5.26	460.5	1.45	8.5	
Above Tilton	3.81	452.0	1.16	42.0	36.21
Below Tilton	2.65	410.0	2.15	140.0	
Below Franklin Falls	0.50	270.0	0.50	3.0±	65.12
Mouth of river	....	267.0			

In the lower 2 miles of its course the stream descends like a cataract over ledges of solid rock, the banks being high, rocky, and sometimes abrupt. In the upper part of its course the bed and banks are sometimes of sand and gravel, but there are no low grounds subject to overflow, even were the stream subject to freshets. Being the outlet of the largest lake in New Hampshire, the flow from which is furthermore controlled in the interest of the

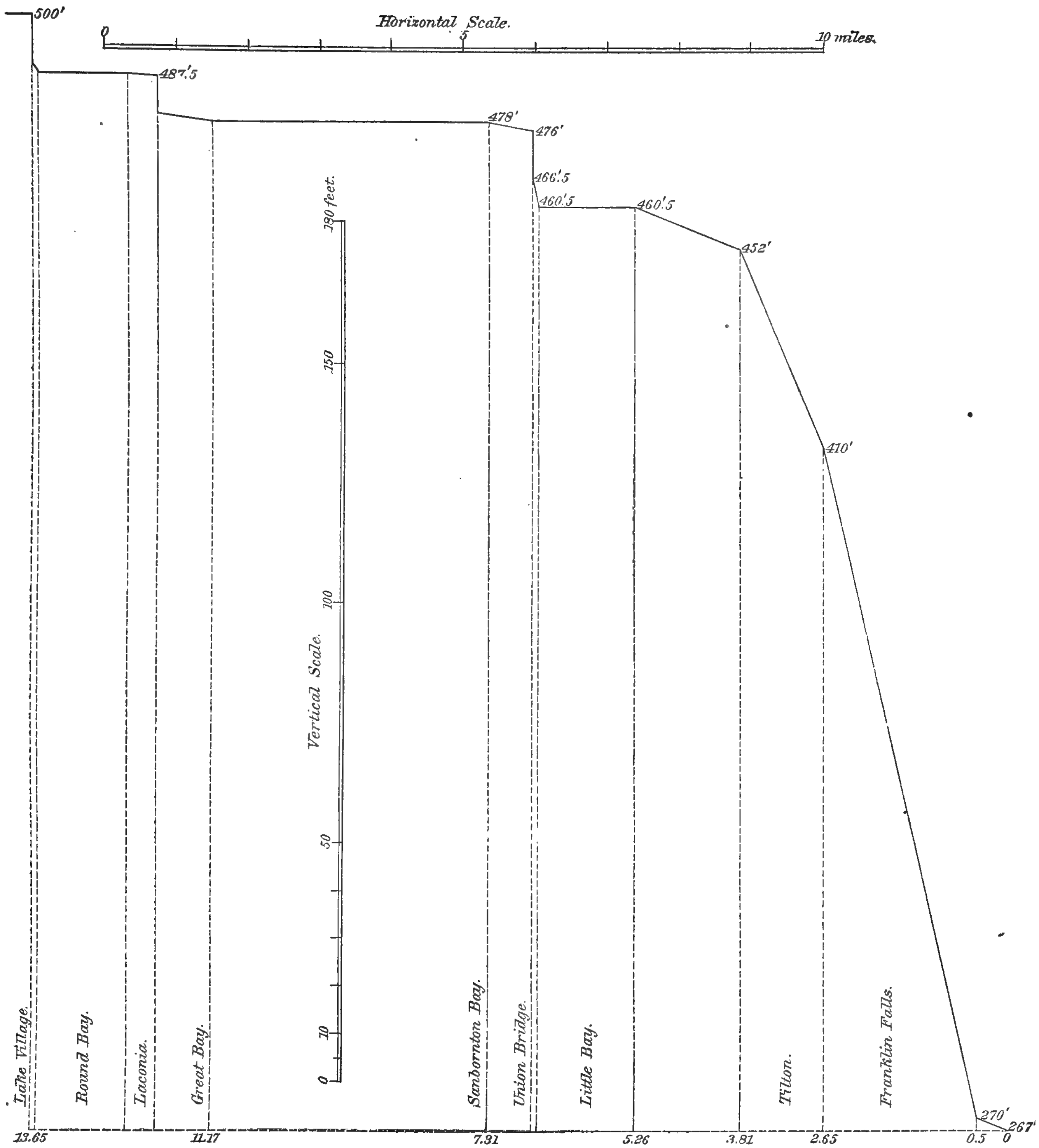

Fig. 15. PROFILE OF THE WINNIPISEOGEE RIVER.

mills lower down on the stream, the volume of water is remarkably constant. Even were the lake not controlled, the volume of the river would be comparatively constant, but being regulated, the water-power below is considerably improved. In the summer-time, namely, when other streams are at their lowest, the corporations at Lowell and Lawrence are drawing heavily on the lake, and there is a heavy flow on the Winnipiseogee. Were the flow of the lake under absolute control of the Lake Company, there would be times when it might desire to retain all the water, allowing none to flow down the Winnipiseogee; but in order to prevent this injury to the water-powers on the latter stream, that company is obliged to allow a very considerable quantity to flow past its dams at Lake Village and at Union bridge—continuously at Union bridge, but during the day-time at Lake Village. The minimum power of this river, then, is very considerable, and the stream is, in fact, one of the most favorable in the state or in the country as a source of power. It is astonishing to see the large quantity flowing down the Winnipiseogee in the summer-time, when other streams are almost dry. The extreme range of water on the lake is about $5\frac{1}{2}$ feet, of which about 18 inches are not controlled, but goes over the dam in freshets, the lowest level being about 4 feet below the top of the dam. The river, however, scarcely knows a freshet, as it is ordinarily understood, the water seldom rising over 3 or 4 feet. The storage capacity of the lake is probably at least great enough to store a depth of 3 or 4 inches over the water-shed tributary to it, or a depth sufficient to render available the maximum flow possible continuously. (See pages 8–10.)

A map of the drainage basin of the Winnipiseogee river is shown in Fig. 16. It comprises a hilly country, tolerably well wooded, the rainfall over which averages about 44 inches, 11 falling in spring and in summer, 13 in autumn, and 9 in winter. The tributaries of the stream are small and unimportant. A railroad follows the river for its entire length, rendering every point easy of access.

The powers on the stream are as follows:

The large fall near the mouth, at Franklin Falls, is controlled by Franklin Falls Water Power Company, and affords a power that will bear comparison with the great powers on the Merrimack. There are six dams within a distance of 2.15 miles. The first or lowest, as the river is ascended, is of wood, 9 feet high and 60 feet long, with flash-boards 5 feet high, making the fall 14 feet, which is used on both sides of the river; on the north by the Winnipiseogee Paper Company, using 500 horse-power; and on the south by A. W. Sulloway's hosiery-mill, with 50 or 60 horse-power. The paper-mill runs night and day, the other only in the day-time. No steam is in use, but at times, however, there is no waste of water. One-third of the power is owned by A. W. Sulloway, and two-thirds by the paper company. The maximum power used is much in excess of that afforded by the minimum flow, because in the paper-mills extra wheels are on hand to be run when there is an abundance of water.

The second dam is about 4,200 feet above the first, but between the two there is an unimproved fall of about 19 feet, corresponding to a minimum power of several hundred horse-power. The second dam, built of wood, is 100 feet long and 14 feet high, with 18 inches of flash-boards. The fall is 14 feet, and is used on the south side by the Franklin woolen-mill, using 100 horse-power, and on the north side by the hosiery-mill of Walter Aiken, using 200 (?) horse-power. Full capacity is always obtained, and no steam is necessary.

The third dam, built of wood, is 720 feet above the second, and is about 100 feet long and 11 feet high, with 2 feet of flash-boards. The power is used on the south side by the Winnipeseogee Paper Company, with a fall of 16 feet, and about 500 horse-power in all, and by the Clark & Haynes machine-shop, using only a fall of 13 feet and 30 horse-power; and on the north side by Sleeper's sash-and-blind mill, with a fall of 12 feet and 32 horse-power, and by Call's grist-mill, with a fall of 12 feet and 25 horse-power.

The fourth dam is 650 feet above the third, and is of wood, 125 feet long and 20 feet high, with 2 or 3 feet of flash-boards. It supplies the pulp-mill of the paper company, where the fall is 20 feet, and the power used some 1,000 horse-power.

The fifth dam is a new dam, built in 1881, while all the others were built many years ago. It is about 1,500 feet above the fourth, and between the two there is an unimproved fall of about 16 feet, capable of affording a minimum power of several hundred gross horse-power. The fifth dam is of wood, 90 feet long and 27 feet high, affording a fall of 27 feet, which is used at a pulp-mill of the paper company, where about 1,400 horse-power are used.

The sixth dam is about 4,300 feet above the fifth, and is of wood, 100 feet long and $7\frac{1}{2}$ feet high, including 2 feet of flash-boards. The fall is 14 feet, used by a third pulp-mill, with nearly 700 horse-power.

Almost the entire power on these falls is controlled by the Franklin Falls Water Power Company, and power is rented, with land, at special rates, according to circumstances. The Winnipiseogee Paper Company owns the controlling interest in the water-power company. The minimum power which would be afforded continuously by the total fall of 140 feet at Franklin Falls is several thousand gross horse-power. The ponds are all too small to allow of the concentration of power into the day-time, but as the principal part of the power is used by the paper-mills, which run day and night, this is not desired. Scarcely any power in New England can compare with this one for constancy of flow and for generally favorable circumstances.

The next power on the stream is at Tilton, where there is a fall of about 42 feet in a little over a mile, with four dams. The lowest affords a fall of $10\frac{1}{2}$ feet, used to run a woolen-mill, with 30 or 40 horse-power. Just below this mill a fall of 7 or 8 feet is unimproved. The next dam above affords a fall of 10 or 12 feet, and is used on the

north bank by the Winnisquam cotton-mill, with 125 or 150 horse-power, and a hosiery-mill on the south bank, with 25 or 30 horse-power. The third dam is a movable "needle" dam, made by supporting vertical planks against sills above and below. The fall is 6 feet, used on both sides, by a woolen- and a grist-mill. The fourth dam affords a fall of 7½ feet, which is used on the south side by the Granite woolen-mill, with about 50 horse-power, and on the north bank by a saw-mill, leasing power of the Granite Company. The whole power at this dam is owned by the Lake Company, and a rent of $300 per annum is paid for it.

Between the last mill and Little bay is a site not used, where there was formerly a saw-mill. The fall, however, is not very large, and the power is not spoken of as a very good one.

At Union bridge, between Little and Sanbornton bays, is the dam of the Lake Company, built of stone and wood, and provided with gates for regulating the amount of water allowed to pass. The power afforded is used by a small saw- and grist-mill, discharging the water into Little bay, and using a fall of about 10 feet. There is considerable fall below the dam, which is from 7 to 10 feet high, and the total fall to Little bay from the pond above the dam is about 17 feet, which might be utilized without difficulty. At present the mill cannot be run uninterruptedly, the water being at times allowed to flow over the dam, where its quantity can be measured, instead of through the race. There seems no reason, however, why, with proper arrangements, a large power could not be used here.

The next power on the stream is at Laconia, above Great bay. The dam at this place is of wood, about 50 feet long and 6½ feet high. From it a canal extends on each side of the river, supplying the following mills, all with falls of 8 feet:

	Proportion of total power.
On the north side:	
J. W. Busiel & Co.'s hosiery-mill	$\frac{3}{24}$
L. F. Busiel's hosiery-mill	$\frac{1}{24}$
Marshall Brothers' yarn-mill	$\frac{8}{24}$
Total	$\frac{1}{2}$
On the south side:	
W. H. Abel & Co's machine-shop; William Busiel's shoddy-mill	$\frac{4}{32}$
Pitman Manufacturing Company's hosiery-mill	$\frac{5}{32}$
Laconia grist-mill	$\frac{3}{32}$
Guilford hosiery-mill	$\frac{4}{32}$
Total	$\frac{1}{2}$

This power is owned by the mill-owners in common, in the above proportions, but no measurements are made of the quantity used by each, or precautions taken to secure the proper distribution, the sizes of the wheels forming the only data. No steam-power is in use, and there is during the greater part of the time no waste of water whatever. In addition to these mills there are three others, taking water from a canal on the north side, which runs from above the dam. These mills are the Winnipiseogee hosiery-mill, with about 25 horse-power; W. S. Thomas' machine-shop, with 10 horse-power; and the Laconia car-shops, with perhaps 40 horse-power. The power on this canal is leased as it stands, with room, there being no regular rate for power.

The only remaining power on the Winnipiseogee is at Lake village. The dam at this place belongs to the Lake Company, which also owns all the water-power rights, and is of stone and wood, about 10 feet high and 250 feet long. The discharge is regulated by gates, as at Union bridge. When water is ordered from Lowell or Lawrence, the necessary quantity is allowed to pass the lower dam, the same quantity being also allowed to pass that at Lake Village, hence water is received at Lowell sooner than if the only dam were that at Lake Village, for then the intermediate bays would first have to be filled. The power at Lake Village is used on both banks. On the right are the company's grist-mill, with 30 horse-power; Bartlett's hosiery-mill; the Howard twine-mill, with 40 horse-power; and the Union Lace Company, with about 100 horse-power. On the left are the company's saw-mill, with 25 or 30 horse-power; Holt & Co.'s hosiery-mill; Brown, Wood & Kingman's hosiery-mill; the Cox Needle Company, with 8 horse-power; Cole's foundery and machine-shop, with 115 horse-power, partly sublet; and the railroad repair-shops, with 35 or 40 horse-power. In most cases the buildings are owned by the Lake Company, and the power and buildings are rented as they stand, there being no regular rate for power. In the case of the Cole Manufacturing Company and the railroad repair-shops, the power is held by a perpetual lease.

The tributaries of the Winnipiseogee river are of small importance. The only one worth mentioning—Tioga river—rises in a reservoir in Gilmanton, and enters the river between Tilton and Little bay. It affords power to a hosiery-mill at Belmont, using 96 horse-power, with a fall of 32 feet. The reservoir covers 137 acres, and can be drawn down 15 feet.

The tributaries of the lake are also not of great importance, and are all small streams, the divide between the lake and adjacent streams lying nowhere more than 7 miles from the lake. There are none on the west worth naming. Merrymeeting river, from the south, is the outlet of Merrymeeting pond, which covers about 3.7 square miles, and lies at an elevation of 87 feet above lake Winnipiseogee. Little power, however, is used on the stream

Fig. 16. MAP OF THE DRAINAGE BASIN OF THE PEMIGEWASSET RIVER.

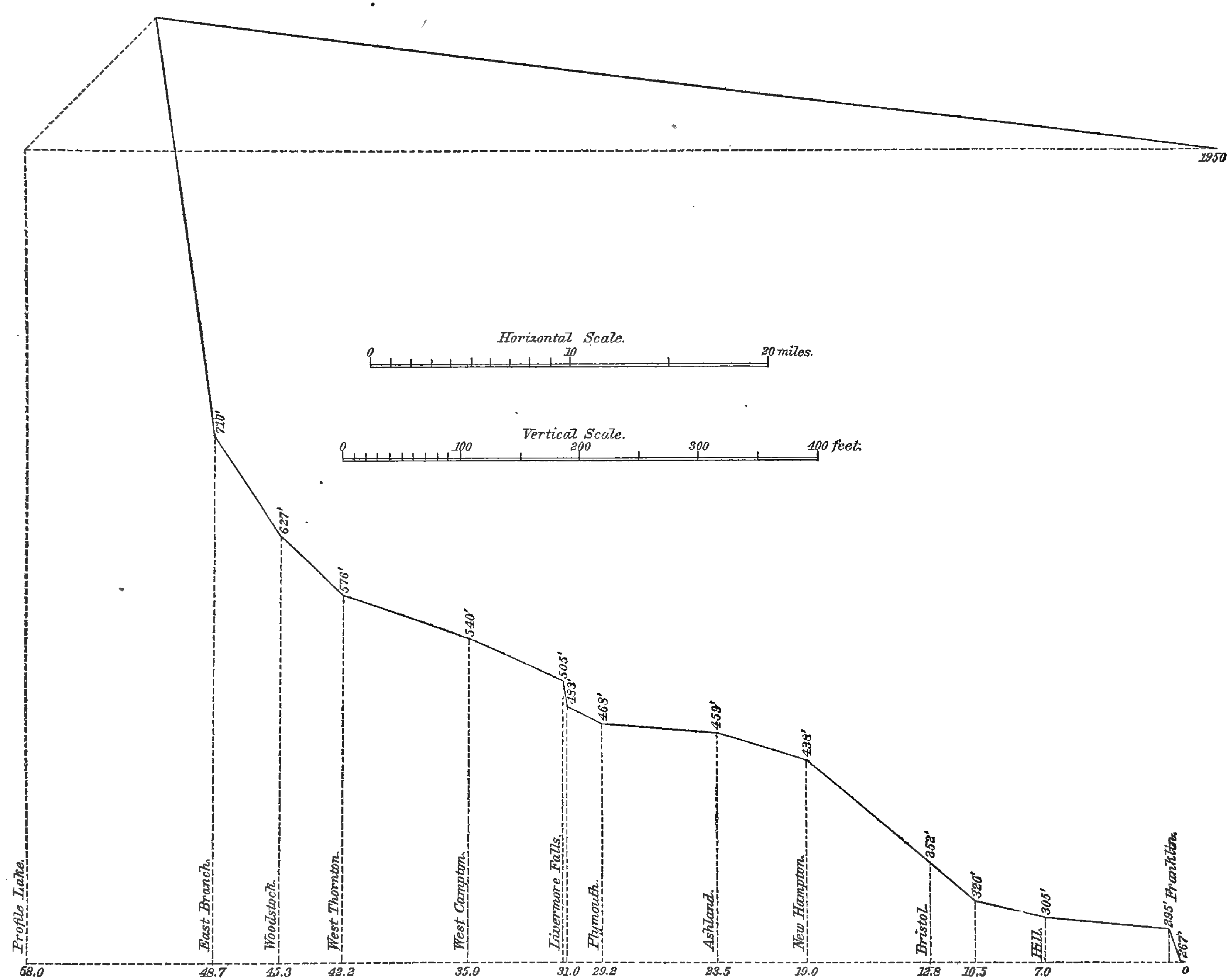

Fig. 17. PROFILE OF THE PEMIGEWASSET RIVER.

notwithstanding its considerable fall. The lake is not dammed. At Wolfeborough there are some mills on the outlet of Smith's pond, which lies at an elevation of 40 feet above the lake. The pond is dammed, and is controlled by the Lake Company, with power to shut off the flow entirely, and the mills referred to are below the company's dam, there being no power used at the latter. In Moultonborough the outlet of some small ponds runs a few small mills, but the only other stream worth naming is the Wukawan river, which empties at Meredith village. It is the outlet of lake Wukawan, covering 1 square mile, and into which flow Long pond and Hawkins pond. A dam a quarter of a mile below lake Wukawan raises the level of the latter 6½ feet, and that of Long pond 4 feet, the dam itself being about 60 feet long and 11 feet high. The fall from this point to lake Winnipiseogee, in a distance of a few hundred feet, is 42 feet when both lakes are full. The power is owned and controlled by the Meredith Mechanic Association, which owns, also, the land, buildings, machinery, etc., and leases the power as it stands. The mills supplied are the following, all with 42 feet fall: Hodgson's hosiery-mill, 60 horse-power; American Twist Drill Company, 60 horse power; Long's piano shop and Clark's box factory, 60 horse-power; grist-mill, 30 horse-power; Wadleigh Plow Company, 10 horse-power. Full capacity can always be secured, and no steam is used. In dry weather, however, there is no waste at night except from the flumes and penstocks. The power, though small, is an excellent one.

THE PEMIGEWASSET RIVER.

This river, which, by its union with the Winnipiseogee, forms the Merrimack, is a stream essentially different from the one just described. It has its source in the heart of the mountains, in Grafton county, being the outlet of Profile lake, in Franconia, which lies at an elevation of about 1,950 feet above the sea. From this small sheet of water the river descends very rapidly, pursuing a very straight course almost due south for a distance of nearly 40 miles. It then bends and flows west for about 6 miles, turning again at Bristol and flowing nearly south to join the Winnipiseogee. For the lower 23 miles of its course it forms the boundary between Belknap county on the east and Grafton and Merrimack counties on the west. Its total length along its course is about 58 miles; its drainage area measures about 1,013 square miles; and the principal towns on its course are Franklin, Hill, Bristol, New Hampton, Ashland, and Plymouth. Its drainage area is mountainous and hilly, and in the upper part is quite thickly covered with woods, probably nine-tenths of the area above Plymouth (*a*) and two-thirds of that southward being covered with forests. The fall of the stream is rapid, as the following table shows, but is for the most part gradual, except in the upper part. The bed and banks in the lower part are mostly of gravel and sand, and the stream is bordered in places by alluvial lands from half a mile to a mile in width, which, however, are seldom overflowed:

Declivity of the Pemigewasset river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Profile lake, source of river	58.0	1,950	9.6	1,240	133.33
Mouth of East branch	48.7	710	3.4	83	24.41
Woodstock	45.3	627	3.1	51	16.45
West Thornton	42.2	576	6.3	36	5.71
West Compton	35.9	540	4.7	35	7.45
Livermore falls (above)	31.2	505	0.2	22	110
Livermore falls (below)	31.0	483	1.8	15	8.33
Plymouth	29.2	468	5.7	9	1.58
Ashland	23.5	459	4.5	21	4.67
New Hampton	19.0	438	6.2	86	13.87
Bristol	12.8	352	2.3	32	13.91
Mouth of Smith's river	10.5	320	3.5	15	4.29
Hill	7.0	305	6.2	10	1.61
Franklin (above falls)	0.8	295	0.6	26	43.33
Franklin (below falls)	0.2	269	0.2	2	10
Mouth	....	267			

NOTE.—These figures are taken from the *Geology of New Hampshire*, Vol. III.

In the upper part, above Thornton and Compton, the river valley is narrow and closely bordered on both sides by mountain ranges, the bed and banks being rocky and the falls abrupt. Draining, as it does, a mountain region,

a *Geology of New Hampshire*, Vol. I, p. 306.

the flow of the stream is very variable, especially as there are no large lakes to render it constant. Only on two of its tributaries is artificial storage made use of to any extent, and these join the river in the lower part of its course. A few estimates of the flow are presented in the following pages. The rainfall over the basin is about the same as over that of the Winnipiseogee, or about 44 inches, of which 11 fall in spring and in summer, 14 in autumn, and 8 in winter. The stream is accessible by rail between Franklin and Bristol and between Ashland and Plymouth, and a new railroad is now being built above Plymouth, rendering the upper parts easier of access.

Notwithstanding the great fall of the river, its water-power is almost unimproved. Not a mill occurs on the lower 31 miles of its course, and above that point it is so small and so variable as to be of little value. Several falls occur, however, within this distance which deserve mention. The first is at Franklin, being really a continuation of the fall on the Merrimack just below the junction of the two headwaters. The principal part of the fall, however, occurs just above the town, where within a distance of less than three-quarters of a mile the stream descends 26 feet. In the upper part the fall is about 15 or 20 feet in a quarter of a mile, over a bed of rock and bowlders, with high banks. The general location would admit of the utilization of the power, though it has never been attempted. The drainage area being about 994 square miles, I should make an estimate of the power about as follows:

Estimate of power of the Pemigewasset river at Franklin.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) continuously.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	15 *feet fall.*	26 *feet fall.*
Minimum	994	200	22.7	340	590
Minimum low season		250	28.4	426	738
Maximum, with storage		600	68.2	723	1,773
Low season, dry years		290	33.0	495	858

There is no fall of importance between this point and the mouth of Smith's river, a small fall at Hill being valueless. From the mouth of Smith's river the fall is rapid all the way to New Hampton, but the greater part, known as Bristol falls, occurs in about a mile, near the town. The bed is of gravel and bowlders, and the banks are tolerably high. This site has never been used. An estimate of the power available might be given somewhat as follows:

Estimate of power at Bristol.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) continuously.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*
Minimum	754	125	14.2
Minimum low season		150	17.0
Maximum, with storage		450	51.1
Low season, dry years		176	20.0

Of the total fall referred to it is said that 14 feet could be utilized without a dam, and with a canal 2,800 feet long.

Between New Hampton and Ashland there is a site formerly used, but not of much importance. The stream is rocky and the banks are high all the way between Bristol and New Hampton, but above that point, and especially above Ashland, the valley opens out, the fall is less, and the bed and banks are often sand. Two more small falls, of 4 or 5 feet, occur between New Hampton and Ashland. Thence up to Plymouth, and above, the stream is very flat and the banks sandy, the river frequently changing its channel. The principal fall in this part of the river occurs at Livermore falls, 2 miles above Plymouth. A wooden dam 28 feet high, on a ledge of rock, ponds the water only a few hundred feet, but the fall used is only 18 feet, the rest being wasted. The power is used for an excelsior-mill and a tannery. The fall is rapid above this place, and numerous sites could be found where power might be developed, but no mills are now running. The quantity of water is very small in the summer, and the power is therefore exceedingly unreliable.

It would seem, then, that various causes have combined to prevent the utilization of the power of the Pemigewasset, namely, the fact that the smaller tributaries have generally sufficed for the small mills seeking power in this vicinity, and the variability of flow of the main river, together with the greater difficulty and cost of utilizing it, especially as the bed and banks are generally gravel or sand. The tributaries of the Pemigewasset are, therefore, of greater importance than the main stream as sources of power.

TRIBUTARIES OF THE PEMIGEWASSET RIVER.—At Franklin a small stream enters from the west, the outlet of Webster pond, affording small but constant power. Its fall is very large, and is all utilized.

Smith's river, from the west, emptying about 2 miles below Bristol, drains about 80 square miles. Its fall is rapid for several miles from its mouth, amounting, it is said, to several hundred feet in that distance, of which, however, only about 25 or 30 feet are utilized. Within half a mile of the mouth the fall is said to be nearly 100 feet. Above Danbury the river has little fall. Its flow is exceedingly variable, there being no lakes of importance tributary to it, and in the summer it is almost dry. Had it equally large reservoirs it might be as valuable a stream as New Found or Squam rivers, described below.

New Found river, which joins the Pemigewasset at Bristol, is a stream similar to the Winnipiseogee, though much smaller. It is the outlet of New Found lake, a sheet of water covering about 7.8 square miles, and lying at an elevation of about 597 feet above the sea. (*a*) The stream is only between 2 and 3 miles in length, but its descent in that distance is about 238 feet, the greater part of this fall occurring at the lower end, where it pours in successive cataracts over ledges of rock. The total drainage area of the stream is about 95 square miles; that of the lake is almost as large. The lake is one of the reservoirs of the Lake Company, and its level has been raised about 7 or 8 feet by a dam, affording a large storage capacity, probably sufficient to store a depth of 3 or 4 inches on the entire drainage area, or enough to render available the maximum flow possible continuously. (See pages 8–10.) We have here, then, as in the case of the Winnipiseogee, an example of a stream reservoired to its full capacity, so that no additional reservoirs could render permanently available during a number of years a greater flow than would now be afforded were the discharge made uniform. As in the case of the Winnipiseogee, the flow is partially controlled by the Lake Company, and there is generally most water flowing in the summer, when other streams are suffering from lack of water. The powers on the stream are the following: At the outlet of the lake a saw-mill belonging to the Lake Company, runs part of the year; within the next half-mile there is an unutilized fall of between 10 and 20 feet; then comes a woolen-mill, with a fall of 6 or 7 feet, now not running; then a saw-mill, with a fall of 12 feet; then Mason, Perkins & Co.'s paper-mill, with a fall of 22½ feet, and about 200 horse-power, running day and night; then a grist-mill, with 13 feet fall; then the New Hampshire Chemical Pulp and Paper Company, with about 15 feet; then Holden's woolen-mill, with 16 feet, and not over 30 horse-power; then Mason, Perkins & Co.'s straw-board mill and a tannery, with 13 feet. This brings us to the bridge at Bristol, 900 feet from the mouth of the river. Between this point and the lake the utilized fall is therefore about 110 feet, and the fall still unutilized about 25 feet. In the last 900 feet of its course the river falls 103½ feet, and the power is used in a very complicated and wasteful manner by a large number of mills, which it is not necessary to describe. The water is distributed in a crude and unscientific manner, but the mills generally can run almost all the time, and no trouble ensues.

The next stream of importance is *Squam river*, a stream similar to that just described, being the outlet of Great and Little Squam lakes, which cover together about 11.75 square miles, and lie at an elevation of about 510 feet above the sea. It is about 2½ miles long, falling 111 feet, and entering the Pemigewasset at Ashland. It drains a total area of about 67 square miles, and the lakes but little less. The latter are controlled by the Lake Company, and a dam about 15 feet high, near the outlet of Little Squam lake, raises the level of both lakes some 4 or 5 feet, affording probably sufficient storage capacity to render available the maximum flow permanently possible, so that we have here a third example of a stream reservoired to its full capacity. The Lake Company allows a considerable quantity of water to flow continuously past its dam, thus affording excellent powers on the stream below, the fall being utilized by a number of mills, as follows:

At the upper dam a saw-mill is operated by the Lake Company, running part of the year; next below is a grist-mill, also owned by the company; then comes a woolen-mill, with 15 feet and about 50 horse-power, and a leather-board mill, with 40 horse-power; below is a new hosiery-mill and a straw-board mill, neither in operation, with a fall of 16 feet; then a paper-mill, with 15½ feet and about 60 horse-power; then a tannery, with 14 feet and 45 horse-power; then a paper-mill, with 17½ feet and 150 horse-power; and, finally, within a mile of the mouth of the stream, a leather-board mill, with 11 feet. There is little fall not used on the stream, except at the unutilized site mentioned above.

The remaining tributaries of the Pemigewasset are of small importance, draining a mountainous country, and with very variable flow, though with large fall. *Baker's river*, which empties from the west, just above Plymouth, drains about 220 square miles, but in the lower part of its course is bordered by alluvial lands, and has little power, while on its upper parts a few small saw-mills run part of the year. The bed and banks on the lower parts are sandy and gravelly, and subject to considerable changes in freshets. *Mad river*, which enters from the east, a little farther up, has considerable fall, deriving its name from its rapid current, and is utilized at Compton and other places by mills of various kinds. The *East branch* of the Pemigewasset drains a wholly uninhabited region of some 115 square miles. On these upper tributaries many cataracts are to be found, but they are of no value for power.

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a Geology of New Hampshire, Vol. I, p. 308.

The following tables give the drainage areas of the tributaries of the Merrimack, and the power utilized on them. In glancing over the figures one will observe the enormous power which this drainage basin affords. The total net horse-power utilized is, in round numbers, 78,600 on the main stream and its branches, or about 16 horse-power per square mile of area:

Table of drainage areas of the Merrimack river and tributaries.

Stream.	Tributary to what.	Above what point.	Drainage area.	Stream.	Tributary to what.	Above what point.	Drainage area.
			Sq. miles.				*Sq. miles.*
Merrimack river	Atlantic ocean	Franklin	1,493	Suncook river	Merrimack river	Mouth of Little Suncook	168
Do	do	Sewell's falls	2,350	Do	do	Short falls	220
Do	do	Garvin's falls	2,412	Do	do	Mouth	264
Do	do	Hooksett	2,791	Little Suncook river	Suncook river	do	44
Do	do	Manchester	2,839	Soucook river	Merrimack river	do	90
Do	do	Lowell	4,085	Contoocook river	do	Peterborough	68
Do	do	Lawrence	4,599	Do	do	Bennington	194
Do	do	Newburyport	4,916	Do	do	Hillsborough	359
Powow river	Merrimack river	Mouth	50	Do	do	Henniker	388
Shawsheen river	do	do	72	Do	do	West Hopkinton	423
Spicket river	do	do	79	Do	do	Contoocook	593
Beaver brook	do	do	92	Do	do	Mouth	766
Sudbury river	Concord	do	150	Nubanusit river	Contoocook	do	56
Assabet river	do	do	175	North branch of	do	do	127
Concord river	Merrimack river	North Billerica	355	Warner river	do	do	149
Do	do	Mouth of Meadow brook	361	Blackstone river	do	Cilleyville	67
Do	do	Mouth	380	Do	do	Mouth	132
Stony brook	do	do	35	Winnipiseogee river	Merrimack	Outlet of lake	348
Nashua river	do	Junction of two branches	256	Do	do	Lake Village	357
Do	do	Mouth	516	Do	do	Laconia	367
North branch of	Nashua river	do	127	Do	do	East Tilton	423
South branch of	do	do	129	Do	do	Tilton	466
Squanacook river	do	do	70	Do	do	Mouth	486
Nissitissit river	do	do	54	Merrymeeting river	Lake Winnipiseogee	do	37
Stillwater river	South branch of the Nashua river.	do	37	Pemigewasset river	Merrimack river	Livermore falls	398
Quinepoxet river	do	do	54	Do	do	Bristol falls	754
Souhegan river	Merrimack river	Wilton	67	Do	do	Franklin falls	994
Do	do	Mouth	224	Do	do	Mouth	1,013
Stony brook	Souhegan river	do	30	Smith's river	Pemigewasset river	do	80
Baboosic brook	do	do	51	New Found river	do	do	95
Cohass brook	Merrimack river	do	68	Baker's river	do	do	220
Piscataquog river	do	do	214	Squam river	do	do	67
South branch of	Piscataquog river	do	100	Mad river	do	do	66
North branch of	do	do	77	North branch of	do	do	28
Suncook river	Merrimack river	Pittsfield	133	East branch of	do	do	115

Table of power utilized on the tributaries of the Merrimack river.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Powow river	Merrimack river	Massachusetts	Essex	Woolen	1	66	1,765
Do	do	New Hampshire	Rockingham	Flour and grist	1	7	80
Do	do	do	do	Saw	[illegible]	18	55
Shawsheen river	do	Massachusetts	Essex	Twine	2	19	225
Do	do	do	do	Woolen	2	23	275
Do	do	do	do	Saw	1	13	5
Do	do	do	Middlesex	Flour and grist	1	12	20
Do	do	do	do	Saw	1	12	20
Do	do	do	do	Wooden-ware	1	8	100
Spicket river	do	do	Essex	Bagging	1	40	62
Do	do	do	do		1	15	....
Do	do	do	do	Woolen	1	12	80
Do	do	do	do	Cotton	1	39	300
Do	do	do	do	Worsted	1	12	140
Do	do	New Hampshire	Rockingham	Hosiery	1	10	40
Do	do	do	do	Woolen	1	15	75

Table of power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Spicket river	Merrimack river	New Hampshire	Rockingham	Box	1	8	30
Do	do	do	do	Saw	2	30	92
Beaver brook	do	do	do	Box	1	12	8
Do	do	do	do	Carriage materials	1	10	50
Do	do	do	do	Cutlery	1	12	15
Do	do	do	do	Flour and grist	2	20	80
Do	do	do	do	Saw	3	39	110
Do	do	do	do	Musical instruments	1	5	6
Do	do	do	Hillsborough	Flour and grist	1	11	30
Do	do	do	do	Saw	1	7	12
Do	do	do	do	Woolen	1	7	20
Do	do	Massachusetts	Middlesex	do	2	34	290
Do	do	do	do	Flour and grist	1	9	20
Do	do	do	do	Paper	1	10	46
Concord river	do	do	do	Dye-woods, etc	1	11	200
Do	do	do	do	Flour and grist	1	....	30
Do	do	do	do	Bolts, nuts, etc	1	22	50
Do	do	do	do	Tannery	1	....	12
Do	do	do	do	Mattresses, etc	1	....	40
Do	do	do	do	Machinery	2	18	35
Do	do	do	do	Paper	1	7	42
Do	do	do	do	Worsted	1	10	40
Do	do	do	do	Woolen	8	122	860
Sudbury river	Concord river	do	do	do	2	50	(?)600
Do	do	do	do	Boots and shoes	1	8	5
Do	do	do	do	Boxes	1	4	20
Do	do	do	do	Saw	2	18	16
Do	do	do	Worcester	Woolen	1	24	115
Do	do	do	do	Carriage and wagon materials	1	16	15
Do	do	do	do	Flour and grist	2	34	59
Assabet river	do	do	Middlesex	Boots and shoes	1	10	45
Do	do	do	do	Flour and grist	1	12	20
Do	do	do	do	Gunpowder	1	11	200
Do	do	do	do	Paper	1	10	75
Do	do	do	do	Woolen	3	48	640
Do	do	do	do	Cotton	1	8	40
Do	do	do	Worcester	Woolen	2	29	178
Do	do	do	do	Fertilizers	1	8	30
Do	do	do	Worcester	Flour and grist	2	29	70
Do	do	do	do	Ivory and bone work	2	17	30
Do	do	do	do	Saw	4	45	192
Do	do	do	do	Wood-turning	1	9	12
Other tributaries of the	do	do	Middlesex	Cotton	1	16	25
Do	do	do	do	Cooperage	2	16	14
Do	do	do	do	Flour and grist	11	135	447
Do	do	do	do	Fertilizers	1	15	25
Do	do	do	do	Saw	7	95	205
Do	do	do	do	Machinery	3	....	44
Do	do	do	do	Musical instruments	1	8	20
Do	do	do	do	Pencil lead	1	11	20
Do	do	do	do	Shoddy	1	16	40
Do	do	do	do	Wheelwrighting	2	22	7
Do	do	do	do	Tools	1	11	25
Do	do	do	do	Vinegar	1	10	7
Do	do	do	Worcester	Boots and shoes	1	7	6
Do	do	do	do	Combs	1	12	10
Do	do	do	do	Flour and grist	7	83	207
Do	do	do	do	Saw	3	36	87
Do	do	do	do	Rubber goods	1	22	50
Do	do	do	do	Vinegar	1	16	40
Do	do	do	do	Wheelwrighting	1	8	12
Stony brook	Merrimack river	do	Middlesex	Hosiery	1	....	150
Do	do	do	do	Worsted	3	52	380
Do	do	do	do	Woolen	1	16	101
Do	do	do	do	Saw	1	7	30
Do	do	do	do	Flour and grist	1	7	33

Table of power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Stony brook	Merrimack river	Massachusetts	Middlesex	Machinery	2	48	95
Do	do	do	do	Shoddy	1	7	60
Do	do	do	Worcester	Leather-board (?)	1	20	55
Nashua river	do	New Hampshire	Hillsborough	Cotton	2	56	2,300
Do	do	Massachusetts	Middlesex	Paper	2	27	418
Do	do	do	do	Saw	1	8	60
North branch of the	Nashua river	do	do	Agricultural implements	1	12	40
Do	do	do	do	Woolen	1	11	40
Do	do	do	do	Blacksmithing	1	7	4
Do	do	do	do	Carpentering	1	10	20
Do	do	do	do	Flour and grist	4	53	240
Do	do	do	do	Flax and linen	1	8	60
Do	do	do	do	Furniture	5	81	90
Do	do	do	do	Leather-dressing	1	9	15
Do	do	do	do	Leather-board (?)	1	9	100
Do	do	do	do	Saw	3	34	110
Do	do	do	do	Shoddy	1	......	32
Do	do	do	do	Machinery	3	......	78
Do	do	do	do	Paper	2	28	235
Do	do	do	do	Printing and publishing	1	......	2
Do	do	do	do	Sash, doors, and blinds	1	11	25
Do	do	do	do	Wood-pulp	1	10	75
Do	do	do	do	Wood-turning	4	......	28
Do	do	do	do	Wooden-ware	1	6	20
Do	do	do	do	Cotton	2	21	160
Tributaries of the North branch of the	do	do	do	Buttons	2	28	40
Do	do	do	do	Jewelry	1	30	20
Do	do	do	do	Cutlery and edge-tools	1	15	30
Do	do	do	do	Machinery	2	10	31
Do	do	do	do	Carriages and wagons	1	25	115
Do	do	do	do	Wagon materials	1	11	20
Do	do	do	do	Combs	5	62	49
Do	do	do	do	Saw	5	64	110
Do	do	do	do	Flour and grist	3	41	66
Do	do	do	do	Furniture	5	60	151
Do	do	do	do	Paper	......	......	1,039
Do	do	do	do	Woolen	3	50	145
Do	do	do	do	Cotton	2	33	158
Do	do	do	do	Musical instruments	1	14	64
South branch of the	do	do	Worcester	Cotton	2	42	886
Do	do	do	do	Comb	1	6	70
Do	do	do	do	Flour and grist	2	19	112
Do	do	do	do	Furniture	1	17	22
Do	do	do	do	Tannery	1	14	25
Do	do	do	do	Saw (?)	1	9	30
Tributaries of the South branch of the	do	do	do	Cotton	10	205	948
Do	do	do	do	Carpet	1	30	30
Do	do	do	do	Woolen	6	142	586
Do	do	do	do	Flour and grist	7	126	303
Do	do	do	do	Saw	7	132	165
Do	do	do	do	Shoddy	3	65	70
Do	do	do	do	Stone- and earthen-ware	1	12	16
Do	do	do	do	Wood-turning	1	18	6
Other tributaries of the	do	do	do	Cotton	3	47	290
Do	do	do	Middlesex	Baskets, etc	1	15	10
Do	do	do	do	Machinery	1	8	10
Do	do	do	do	Blacksmithing	1	10	6
Do	do	do	do	Leather-board	6	77	395
Do	do	do	do	Cutlery	1	12	10
Do	do	do	do	Paper	2	24	210
Do	do	do	do	Flour and grist	8	102	180
Do	do	do	do	Wooden-ware	2	......	41
Do	do	do	do	Furnishing goods	1	14	99
Do	do	do	do	Saw	13	192	414
Do	do	do	do	Wheelwrighting	1	10	10
Do	do	do	Worcester	Saw	7	50+	157

Table of power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of the	Nashua river	New Hampshire	Hillsborough	Furniture	1	12	43
Do	do	do	do	Wheelwrighting	1	10	16
Do	do	do	do	Saw	8	128	418
Do	do	do	do	Silk	1	8	10
Do	Merrimack river	Massachusetts	Essex	Woolen	5	70+	205
Do	do	do	do	Carriages and wagons	1	25	10
Do	do	do	do	Flour and grist	1	13	10
Do	do	do	do	Tannery	1	8	8
Do	do	do	do	Saw	2	29	55
Do	do	do	do	Machinery	1	16	60
Do	do	do	Suffolk	Foundery	1	24	15
Do	do	do	Middlesex	Box	2	31	60
Do	do	do	do	Brooms and brushes	1	8	5
Do	do	do	do	Carpentering	2	24	22
Do	do	do	do	Flour and grist	4	47	100
Do	do	do	do	Saw	4	53	105
Do	do	do	do	Shoddy	1	19	15
Souhegan river	do	do	do	Flour and grain	1	11	10
Do	do	do	do	Saw	4	48	54
Do	do	do	Worcester	do	1	9	20
Do	do	New Hampshire	Hillsborough	Woolen	1	20	65
Do	do	do	do	Cotton	3	22+	734
Do	do	do	do	Worsted	1	32	165
Do	do	do	do	Agricultural implements	2	24	64
Do	do	do	do	Flour and grist	3	39	155
Do	do	do	do	Toys and games	1	18	90
Do	do	do	do	Furniture	3	64	153
Do	do	do	do	Looking-glass	1	9	25
Do	do	do	do	Saw	4	38	180
Do	do	do	do	Shoddy	1	17	20
Tributaries of the	Souhegan river	do	do	Flour and grist	6	84	199
Do	do	do	do	Wood-turning	3	34	31
Do	do	do	do	Furniture	1	12	6
Do	do	do	do	Planing	1	10	35
Do	do	do	do	Saw	14	174	415
Do	do	do	do	Wooden-ware	1	10	10
Do	do	do	do	Stone- and earthen-ware	1	40	20
Cohass river	Merrimack river	do	do	Woolen	1	42	170
Piscataquog river and tributaries	do	do	do	Cotton	1	16	60
Do	do	do	do	Boxes	1	10	15
Do	do	do	do	Cooperage	1	8	22
Do	do	do	do	Flour and grist	5	50	272
Do	do	do	do	Furniture	1	7	6
Do	do	do	do	Planing	1	9	6
Do	do	do	do	Machinery	1	6	3
Do	do	do	do	Saw	24	250	495
Do	do	do	do	Sash, doors, and blinds	1	13	10
Do	do	do	do	Toys and games	2	19	26
Do	do	do	do	Wood-pulp	1	13	167
Do	do	do	do	Wood-turning	1	10	8
Do	do	do	do	Shuttle	1	10	60
Suncook river	do	do	Merrimack	Cotton	5	105	?2,000±
Do	do	do	do	Boots and shoes	1	10	20
Do	do	do	do	Cordage	1	8	29
Do	do	do	do	Flour and grist	5	51	152
Do	do	do	do	Saw	9	81	208
Do	do	do	do	Planing	1	10	20
Do	do	do	Belknap	Woolen	1	7	20
Do	do	do	do	Agricultural implements	1	10	40
Do	do	do	do	Boots and shoes	1	5	10
Do	do	do	do	Flour and grist	3	25	98
Do	do	do	do	Saw	3	32	106
Little Suncook river	Suncook river	do	Merrimack	Flour and grist	2	20	102
Do	do	do	do	Saw	1	11	50
Do	do	do	Strafford	do	1	53	20
Soucook river	Merrimack river	do	Merrimack	Washing-machines	1	......	47
Do	do	do	do	Wheelwrighting	1	12	25

Table of power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Contoocook river	Merrimack river	New Hampshire	Merrimack	Cotton	2	31	500
Do	do	do	do	Furniture	1	12	115
Do	do	do	do	Table	1	12	25
Do	do	do	do	Axles	1	7	60
Do	do	do	do	Sash, door, and blind	1	9	30
Do	do	do	do	Excelsior	1	17	....
Do	do	do	do	Woolen	1	16	35
Do	do	do	do	Saw	5	74	225
Do	do	do	do	Flour and grist	3	42	260
Do	do	do	do	Ax-handles	1	20	....
Do	do	do	do	Saw-works	1	20	....
Do	do	do	do	Granite-polishing	1	20	....
Do	do	do	do	Cooperage	2	20	75
Do	do	do	do	Machinery	1	7	10
Do	do	do	do	Paper	1	12	100
Do	do	do	Hillsborough	Hosiery	1	15	80
Do	do	do	do	Woolen	1	14	90
Do	do	do	do	Needles	1	15	5
Do	do	do	do	Silk	1	15	8(?)
Do	do	do	do	Paper	1	18	120
Do	do	do	do	Agricultural implements	1	10	5
Do	do	do	do	Cutlery	2	19	....
Do	do	do	do	Flour and grist	3	20+	200
Do	do	do	do	Scientific instruments	2	19	58
Do	do	do	do	Saw	5	53+	125
Do	do	do	do	Surgical appliances	1	8	20
Do	do	do	do	Wooden-ware	1	7	40
Do	do	do	Cheshire	Flour and grist	1	12	25
Do	do	do	do	Saw	4	66	185
Do	do	do	do	Cutlery	1	6	20
Do	do	do	do	Wood-pulp	1	18	100
Do	do	do	do	Wooden-ware	2	22	65
Do	do	do	do	Cotton	1	21	125
Blackwater river	Contoocook river	do	Merrimack	Hosiery	1	11	25
Do	do	do	do	Tannery	1	12	32
Do	do	do	do	Wheelwrighting	1	13	15
Do	do	do	do	Saw	6	69	270
Do	do	do	do	Blacksmithing	1	8	8
Do	do	do	do	Leather-board	1	15	70
Do	do	do	do	Flour and grist	3	33	121
Warner river	do	do	do	Carpentering	1	12	25
Do	do	do	do	Paper	1	12	60
Do	do	do	do	Carriage materials	2	19	70
Do	do	do	do	Excelsior	1	22	60
Do	do	do	do	Furniture	1	10	12
Do	do	do	do	Flour and grist	2	16	75
Do	do	do	do	Saw	4	39	151
Nubanusit river	do	do	Hillsborough	Cotton	2	72	288
Do	do	do	do	Baskets, etc	1	12	15
Do	do	do	do	Blacksmithing	1	9	12
Do	do	do	do	Carpentering	1	11	20
Do	do	do	do	Furniture	1	9	50
Do	do	do	do	Foundery	1	....	8
Do	do	do	do	Saw	1	9	50
Do	do	do	do	Paper	2	34	110
Do	do	do	do	Woolen	1	25	25
Do	do	do	do	Wood-pulp	1	26	200
Other tributaries of the	do	do	do	Blacksmithing	2	30	18
Do	do	do	do	Cutlery	1	30	45
Do	do	do	do	Excelsior	1	16	12
Do	do	do	do	Flour and grist	1	....	6
Do	do	do	do	Wire-work	1	14	40
Do	do	do	do	Furniture	3	....	40
Do	do	do	do	Saw	6	108	251
Do	do	do	do	Wheelwrighting	1	....	8
Do	do	do	do	Wood-turning	1	20	16

Table of power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of the	Contoocook river	New Hampshire	Cheshire	Saw	6	76	281
Do	do	do	do	Wooden-ware	6	87	321
Do	do	do	Merrimack	Agricultural implements	1	12	50
Do	do	do	do	Excelsior	1	13	50
Do	do	do	do	Saddlery and harness	1	19	40
Do	do	do	do	Sash, door, and blind	1	12	32
Do	do	do	do	Spools and bobbins	1	11	10
Do	do	do	do	Wheelwrighting	2	16	82
Do	do	do	do	Wooden-ware	2	42	75
Do	do	do	do	Tannery	1	8	12
Do	do	do	do	Flour and grist	2	29	115
Do	do	do	do	Saw	13	212	363
Do	do	do	do	Planing	1	....	10
Do	Merrimack	do	Hillsborough	Cotton	1	26	150
Do	do	do	do	Silk	1	8	10
Do	do	do	do	Carriage and wagon materials	1	....	10
Do	do	do	do	Cutlery	1	22	185
Do	do	do	do	Drugs and chemicals	1	15	25
Do	do	do	do	Files	2	....	28
Do	do	do	do	Flour and grist	2	17	58
Do	do	do	do	Saw	16	238	440
Do	do	do	do	Sash, door, and blind	1	12	35
Do	do	do	do	Wheelwrighting	4	33+	49
Do	do	do	do	Wood-turning	2	....	50
Do	do	do	do	Tannery	1	28	16
Do	do	do	Rockingham	Cooperage	1	12	10
Do	do	do	do	Flour and grist	4	34	115
Do	do	do	do	Saw	20	240	491
Do	do	do	Merrimack	Woolen	1	63	100
Do	do	do	do	Brick and tile	1	16	10
Do	do	do	do	Blacksmithing	3	....	9
Do	do	do	do	Carpentering	1	12	20
Do	do	do	do	Cooperage	1	36	40
Do	do	do	do	Dentistry (?)	2	220	2
Do	do	do	do	Furniture	1	....	10
Do	do	do	do	Flour and grist	5	89	301
Do	do	do	do	Printing and publishing	3	330	12
Do	do	do	do	Saw	10	125+	258
Do	do	do	do	Marble work	1	14	20
Do	do	do	do	Machinery	1	12	150
Do	do	do	Belknap	Watch and clock	1	30	4
Do	do	do	do	Saw	4	50	120
Winnipiseogee river	do	do	Merrimack	Woolen	3	27	180
Do	do	do	do	Paper	1	91	4,100(?)
Do	do	do	do	Sash, door, and blind	1	12	32
Do	do	do	do	Saws	1	13	10
Do	do	do	do	Flour and grist	1	12	25
Do	do	do	do	Machinery	1	13	20
Do	do	do	do	Hosiery	3	38	280
Do	do	do	Belknap	Flour and grist	4	38	175
Do	do	do	do	Car-repairing	2	18	70(?)
Do	do	do	do	Yarn	1	8	....
Do	do	do	do	Woolen	1	10	40
Do	do	do	do	Needles	2	....	18
Do	do	do	do	Cotton	1	10	120
Do	do	do	do	Twine	1	8	40
Do	do	do	do	Lace	1	10	100
Do	do	do	do	Hosiery	3	75	425±
Do	do	do	do	Shoddy	1	8	....
Do	do	do	do	Machinery	3	26	....
Do	do	do	do	Saw	2	19	125
Tributaries of the	Winnipiseogee river	do	do	Cotton	1	32	96
Do	do	do	do	Shoddy	1	28	20
Do	do	do	do	Saw	1	....	6
Do	Lake Winnipiseogee	do	do	Agricultural implements	2	40+	23
Do	do	do	do	Hosiery	1	42	60

Total power utilized on the tributaries of the Merrimack river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of the	Lake Winnipiseogee	New Hampshire	Belknap	Carpentering	1	42	30
Do	do	do	do	Tannery	1	16	20
Do	do	do	do	Musical instruments	1	42	30
Do	do	do	do	Flour and grist	2	52	60
Do	do	do	do	Saw	3	54	99
Do	do	do	Carroll	Furniture	1	14	40
Do	do	do	do	Flour and grist	2	32	100
Do	do	do	do	Saw	5	59	213
Do	do	do	do	Woolen	1	25½	36
Pemigewasset river	Merrimack river	do	Grafton	Excelsior	1	18	50
Do	do	do	do	Tannery	1	18	......
Smith's river	Pemigewasset river	do	Merrimack	Flour and grist	1	10	24
Do	do	do	do	Saw	3	34	120
Do	do	do	Grafton	do	3	101	85
Other tributaries of the	do	do	Merrimack	Surgical appliances	1	10	8
Do	do	do	do	Carriages and wagons	1	15	10
Do	do	do	do	Foundery	1	20	20
Do	do	do	do	Flour and grist	3	61	64
Do	do	do	do	Tannery	1	12	9
Do	do	do	do	Saw	5	61	185
Do	do	do	do	Needles and pins	1	15	6
Do	do	do	do	Hosiery	2	21	35
Do	do	do	Grafton	Clothing	1	16	5
Do	do	do	do	Wheelwrighting	1	11	11
New Found river	do	do	do	Woolen	1	16	30
Do	do	do	do	Paper	3	46	297
Do	do	do	do	Carpentering	2	......	30
Do	do	do	do	Flour and grist	3	30	130
Do	do	do	do	Blacksmithing	1	12	15
Do	do	do	do	Wood-turning	1	16	86
Do	do	do	do	Carriages and wagons	1	12	50
Do	do	do	do	Gloves	1	18	76
Do	do	do	do	Tanneries	2	38	150
Do	do	do	do	Machinery	1	8	2
Do	do	do	do	Straw-board	1	13	......
Do	do	do	do	Wood-pulp	1	22	200
Do	do	do	do	Saw	1	12	50
Squam river	do	do	do	Machinery	1	12	60
Do	do	do	do	Paper	2	33	210
Do	do	do	do	Flour and grist	1	13	40
Do	do	do	do	Tannery	1	14	45
Do	do	do	do	Leather-board	2	26	80
Do	do	do	do	Woolen	1	15	50
Do	do	do	do	Saw	1	15	......
Mad river	do	do	do	Blacksmithing	1	9	35
Do	do	do	do	Furniture	1	14	40
Do	do	do	do	Woolen	1	11	34
Do	do	do	do	Sash, door, and blind	1	14	65
Do	do	do	do	Wood-turning	1	14	40
Do	do	do	do	Saw	1	11	30
Do	do	do	do	Flour and grist	1	14	40
Baker's river	do	do	do	Planing	1	8	20
Do	do	do	do	Saw	3	42	173
Do	do	do	do	Flour and grist	1	18	60
Other tributaries of the	do	do	do	Carpentering	1	10	20
Do	do	do	do	Gloves and mittens	3	27	55
Do	do	do	do	Wooden handles	2	25	45
Do	do	do	do	Saw	32	575	910
Do	do	do	do	Veneering	1	18	20
Do	do	do	do	Tanneries	3	30+	40
Do	do	do	do	Flour and grist	6	115	185
Do	do	do	Carroll	Saw	2	26	50
Do	do	do	do	Flour and grist	1	30	40

Fig. 18. MAP OF THE DRAINAGE BASINS OF THE COAST STREAMS OF NEW HAMPSHIRE.

IV.—THE COAST STREAMS OF NEW HAMPSHIRE.

None of the streams which flow into the Atlantic between the Merrimack and the Piscataqua are of any importance as sources of power, being all very small, and lying in the flat eastern district, subject to grea variations in flow, and with very little fall. The Piscataqua, which is formed by the union of the Cocheco and th Salmon Falls rivers, forms for its entire length the boundary between the states of Maine and New Hampshire, an is tidal and navigable for its entire length, which is only 11 miles. About 7 miles from its mouth it receive the waters of Great bay, a wide tidal basin covering about 9 square miles, and receiving the waters of severa rivers, whose drainage basins are contiguous to that of the Merrimack. The total area in New Hampshire draining into the Atlantic, either through the Piscataqua or, directly, by some of the small streams between Great bay an the coast, is about 825 square miles. (*a*) The total area drained by the Piscataqua in Maine and New Hampshir is about 550 square miles. (*b*) It comprises a region for the most part level, about one-third covered with forest, (*b* crossed by numerous railroads, and showing a few considerable water-powers. The tributaries of the Piscataqu will be described in their order, commencing at the south.

THE EXETER RIVER.

The Exeter river takes its rise in the eastern part of Rockingham county, and pursues a general easterly cours for about 17 miles, measured in a straight line, flowing then nearly north for about 6 miles, passing the town o Exeter, and emptying into Great bay. The head of tide and of navigation is Exeter, where the tide rises 4 or 5 feet and up to which place boats of 80 tons ascend. The stream is separated from the Merrimack by a comparativel low water-shed, and drains a total area of about 113 square miles, above Exeter, comprising a flat country, wit scarcely any lakes or reservoirs, though there are, no doubt, facilities for storage. Its basin is very full of drift The stream is narrow and very crooked, the bed is generally clay, sand, or gravel, and the banks are generally hig enough to prevent overflow. Phillips pond, at the head of the stream, covers about 160 acres, and is 215 fee above the sea; and as the stream is probably 40 or 50 miles long, if all its windings are followed, its declivity i probably not over 4 or 5 feet per mile. Its flow is so variable, being almost nothing in the summer-time, that th stream is of little value as a source of power.

The first power is at Exeter, where a wooden dam 11 feet high ponds the water for 5 or 6 miles, and, with a rac of 800 feet in length, affords a fall at low water of 21 feet, and at high water of 17 feet, at the cotton-mill of the Exete Manufacturing Company. A power of 250 horse-power is used during eight months, while during the remainin four months the power is very small, there being sometimes, for several weeks at a time, only enough water for th boilers. Steam-power is used to the extent of 300 horse-power. Nine miles above this point, by the course of th river, is a grist-mill, with a fall of 12 feet. Above that is an unutilized privilege, with a fall of 10 feet, once use by a paper-mill; but it is only good during about eight months of the year. Still farther up, but only a mile or s above the grist-mill, is a second unutilized privilege, known as the "Pickpocket" site, abandoned two years ag because the power was so small. The fall is 11 feet, and it was occupied by a paper-mill. Above this are a numbe of other small powers, not worthy of special mention; they are of some value during about eight months of the yea but during the rest of the time the power is not worth utilizing.

THE LAMPREY RIVER.

The Lamprey river, the next tributary of Great bay, resembles in general character the Exeter, except that i is more favorably circumstanced as regards storage. Rising in the northwestern part of Rockingham county, i pursues a devious course, and empties into Great bay at a point about 18 miles from its source, in a direction little south of east. It is navigable and tidal as far as the town of Newmarket, about 14 miles from Portsmouth the rise of the tides being about 4 feet. At this place are situated the mills of the Newmarket Manufacturing Company, where, with a wooden dam 20 feet high and 115 feet long, founded on a ledge, and backing the wate about 2 miles, a fall of from 22 to 26 feet is utilized, according to the state of the tide. A short rectangular cana extends on either side of the river to the mills, and the power used is 400 horse-power, which can, however, onl be obtained during about six months. Like the Exeter, the stream is very variable in flow, and in the summe time it almost dries up, notwithstanding the artifical storage. After the reservoirs are emptied, the natural flow o the stream, in dry seasons, would not afford over 50 horse-power during working hours. The mills use, in all, 1,00 horse-power in steam-power, part of which is running all the time. The reservoirs referred to, and which ar controlled by the Newmarket Company, are two in number, viz, Mendam's pond and Pawtuccaway pond. Th

a *Geology of New Hampshire*, Vol. I, p. 313.

b Wells: *Water Power of Maine.*

former covers 250 acres when full, and is dammed to a height of 28 feet, all of which can be drawn off. The watershed of the pond, however, is small, and it is seldom full. Pawtuccaway pond covers some 3,000 acres when full, and has two outlets, both of which are dammed by stone dams, one 20 feet high, from which an outlet runs south, entering the Lamprey at West Epping, and the other 10 feet high, from which an outlet flows east, entering the Lamprey below Epping. Before a depth of 10 feet is drawn from the pond, it divides into two. These ponds are the only ones in the basin which are of any importance, but the facilities for storage are tolerably good, and others could be made, if necessary. Jones' pond, in Raymond, covers about 160 acres, and is 258 feet above the sea.

The total area drained by the Lamprey above Newmarket measures about 210 square miles. Above that place there are no powers of much importance. The first is an unimproved power, known as Packerd's falls, belonging to the Newmarket Company, and situated just at the head of its pond, with an available fall of 20 feet and a power of probably 350 horse-power net during about six months; then a paper-mill, with a fall of 10 feet; then an unutilized site known as Long falls, 5 miles above Newmarket, with a fall of some 6 feet; then a saw- and grist-mill, with a fall of 10 feet or so, just below where the outlet of Mendam's pond comes in. Above this are various small mills not worthy of special mention.

THE OYSTER RIVER.

This, the next tributary of Great bay, is not worth describing. It is a very small stream, tidal to Durham, where there is a saw-mill, and with one small pond tributary to it called Wheelwright's pond, covering about 250 acres, and lying at an elevation of 131 feet above the sea.

THE BELLAMY RIVER.

This, the only remaining tributary of Great bay, is a small stream, but quite a good one for power. The principal site is at the head of tide, near Dover, where are situated Sawyer's woolen-mills, with three dams in succession. The lowest affords a fall of 20 feet, with 80 horse-power; the next two a fall of 12 feet each, with 50 horse-power. These amounts of power may be secured during the entire year. A reservoir in Barrington, called Dodge's pond, covering 445 acres, and dammed to a height of 13 feet, serves to hold considerable water in store. At Sawyer's mills all the water is held except during about two months of the year, when water runs over the dam. At the head of Sawyer's pond is a grist-mill, and nearly 3 miles above an unutilized site, where the available fall is said to be 20 feet. The stream is rather sluggish and affords little power above this. One other pond, known as Swain's pond, covers about 160 acres.

THE COCHECO RIVER.

The Cocheco river, which, with the Salmon Falls, forms the Piscataqua, takes its rise in the extreme northern part of Strafford county, near Merrymeeting lake, from which it is separated by a divide only about 70 feet above the surface of lake Winnipiseogee. It flows in a southeasterly direction by the towns of Farmington, Rochester, Gonic, and Dover, its total length in a straight line being about 25 miles, and its drainage area above Dover, which is the head of tide and of navigation, about 183 square miles. Its drainage basin is not very well wooded, and comprises a considerable extent of flat and sandy country, through which the river flows with a sluggish current. Abrupt descents over ledges of rock interrupt its course at places, however, affording some good powers. The fall of the stream is very rapid above Farmington, being said to be nearly 200 feet in 3 miles. As soon as the river reaches, however, the flat and sandy plain on which Rochester is situated, its current becomes sluggish, until, at Rochester, it descends suddenly over a rocky ledge, to fall again at Gonic and Dover. The banks of the stream are generally firm and high, and very few areas are subject to overflow, though the freshets are quite severe. The flow, however, is by far more constant than that of the streams thus far described, so that the stream is much better adapted for power. It is more extensively reservoired, too, there being the following ponds on the stream and its tributaries:

1. Bow pond, on the Isinglass river, in Strafford, lying at an elevation of 515 feet above the sea, and covering about 1,000 acres. It is dammed to a height of 20 feet, all of which can be drawn off.
2. Ayer's pond, in Barrington, also tributary to the Isinglass, covering about 380 acres, and dammed to a height of 12 feet.
3. Nippo pond, in Barrington, covering about 125 acres, and dammed to a height of 6 feet.
4. Round and Long ponds, tributary to the Isinglass, and covering each about 125 acres, neither being dammed.
5. Reservoir in Middleton, covering about 300 acres, and dammed to a height of 18 feet, 16 feet of which can be drawn off.
6. New Durham reservoir, or Marsh's ponds, comprising two ponds, with, together, about 150 acres, dammed to a height of 12 feet, of which 11 may be drawn off.
7. Coldrain pond, covering 40 acres, and not controlled.

The stream is very easily accessible, being followed by a railroad for its entire length.

The first power is at Dover, at the head of tide. A stone dam 15 feet high and 130 feet long ponds the water for 2 miles, and affords a fall of 36 feet, with scarcely any race, at the cotton-mills of the Cocheco Manufacturing

Company. The bed of the stream is solid rock. The power used is about 1,000 horse-power net, but this can only be obtained during about nine months of the year, steam being in reserve to the extent of 800 horse-power. In the summer time there is no waste whatever, even at night. The company controls Bow pond, Ayer's pond, and Nippo pond, and also has two dams on the river below the mouth of the Isinglass, which serve simply to regulate the flow, being opened every morning and closed every night. One of these dams is 12 feet high and the other 5 feet.

The only other power below the mouth of the Isinglass river is that used by a small grist- or saw-mill. About 2 or 3 miles below Rochester, and a short distance below Gonic, is a fall not used, amounting, it is said, to over 8 feet. A little above is a saw-mill with a fall of 15 feet, capable of being increased to 19 or 20 feet, it is said, by raising the dam. At Gonic a fall of 19½ feet, with 120 horse-power, is used by the woolen-mill of the Gonic Manufacturing Company, with a wooden dam 9 feet high. This power can be obtained all the time by storing the water at night, so that if we take the minimum power of the stream in twenty-four hours at 4 horse-power per foot fall, its minimum flow is about 35 cubic feet per second, or 0.39 cubic feet per second per square mile, the drainage area being 90 square miles.

The next power above is at Rochester, where there are three dams. The lowest supplies a saw- and grist-mill, with a fall of 9 feet. The next supplies one of the woolen-mills of the Norway Plains Manufacturing Company, with a fall of 18 feet on one wheel, 15 feet on another, and 23 feet on another, the total power being about 275 horse-power. Some steam is in reserve, as full capacity can only be secured during eight months. The upper dam supplies another mill of the same company, the fall being 8 feet, and 60 horse-power being used. The bed of the stream at this place is solid rock, and the facilities for the use of power good. The Norway Plains Company controls the reservoirs at Middleton and New Durham.

Above Rochester there are no mills of importance on the stream. At Farmington there are a couple of mills with quite large falls, and above that place, on the two headwaters of the Cocheco, the Ela and Walden, there is considerable fall, but little power, probably none worth developing except for local mills.

The principal tributary of the Cocheco is the Isinglass river, which comes in about 3 miles below Rochester, and on which are the reservoirs of the Cocheco Manufacturing Company. The stream, however, is of small value for power, being an insignificant stream, and its flow being controlled by the above-named company. It has a few small powers.

SALMON FALLS RIVER.

This river, which, with the Cocheco, forms the Piscataqua, takes its rise in Great East pond, which lies partly in Maine and partly in New Hampshire, at an elevation of about 499 feet above the sea. Thence the river pursues a course in a southerly and southeasterly direction, forming for its entire length the boundary between the two states, and flowing by the towns of Milton, East Rochester, Great Falls, Salmon Falls, and South Berwick. Its total length, from its source to its junction with the Cocheco, is 28 miles in a straight line, and its drainage area measures about 334 square miles, of which 215 lie in New Hampshire and 119 in Maine. The stream is navigable to the head of tide-water, at South Berwick, Maine, at which place the first power on the stream is situated. The drainage basin is similar in character to that of the Cocheco, except that it is probably rather more hilly and broken; not one-third of the basin is wooded. The bed of the stream is often solid rock, alternating with gravel, sand, and clay. The banks are generally high, and only small areas are overflowed in freshets. The fall is very considerable, and is broken by the ledges of rock into cataracts and rapids, affording excellent water-powers, many of which are improved. The stream is quite well reservoired, and its flow more constant than that of any stream in the basin we are considering. During the past few years extensive improvements have been made in the reservoirs on the upper waters, by which the power below has been greatly improved. The freshets are not violent enough to cause any trouble or damage. The principal lakes and reservoirs on the stream and its tributaries are the following, the areas being given for full pond:

1. Great East pond, at the head of the stream, covering 1,817 acres, and lying at a height of 499 feet above the sea. It is dammed to a height of 21 feet, nearly all of which may be drawn off.
2. Horn pond, into which the stream flows after leaving Great East pond, covers 224 acres, and is dammed so that a depth of 6 feet may be drawn off. Its elevation is about 478 feet above the sea.
3. Garvin's pond, tributary to Horn pond, covers 285 acres, and is not dammed.
4. Milton Three ponds, comprising South pond, with an area of 390 acres; North pond, with 180 acres, and Northeast pond, with 920 acres, making in all 1,490 acres. The lowest of these ponds, which are all connected with each other, is dammed to a height of 16 feet, so that this depth may be drawn from nearly the whole area. These ponds are on the main stream, 9 miles from Great East pond, and their elevation above the sea is 400 feet.
5. Cook's pond, covering 272 acres, from which 12 feet may be drawn, situated on Branch river, a tributary of the main stream.
6. Lovell's pond, covering 581 acres, from which 16 feet may be drawn, lying on the same stream.
7. Cate's pond, covering 300 acres, from which 6 feet may be drawn, also on Branch river. This pond is entirely artificial.

Besides these ponds, there are other smaller ones. The total number of ponds in the basin of the Piscataqua, according to Wells, is 22, covering a total area of 16 square miles, or one thirty-fourth of the area of the basin. The facilities for storage in the basin are remarkably good, and numerous sites could no doubt be found for additional reservoirs, should they be desired. All of the ponds named above are controlled by the Great Falls Manufacturing Company, of Great Falls, New Hampshire.

The fall of the stream may be seen approximately from the following table:

Declivity of Salmon Falls river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0			
			6	166	27.7
Great Falls, top of dam	6	*a*166			
			6	34	5.7
East Rochester	12	*a*200±			
			7	200	28.6
Three ponds, Milton	19	*a*400			
			8	78	9.7
Horn pond, Wakefield	27	478			
			1	21	2.1
Great East pond, Wakefield	28	*a*499			

a Geology of New Hampshire, Vol. I, p. 313.

The average fall of the stream is, therefore, nearly 18 feet per mile, a very large fall. This, together with the constancy of the flow (a rise of 3 feet in the spring freshets being an unusual occurrence), makes the stream an excellent one for power. It offers a good example of what may be done by careful and scientific improvement of the natural advantages. The maximum power available with storage is probably approached more nearly in the case of this stream than in that of any stream of equal size which we have yet discussed, on the Atlantic slope, excepting the Winnipiseogee river. The rainfall over the basin is about 44 inches, very evenly distributed through the year. The stream is accessible at all points, being nowhere more than a few miles from a railroad.

The first power, as the stream is ascended, is at South Berwick, Maine, at the head of tide, at what is known as "Quamphegan falls". A timber dam, about 14 feet high and about 250 feet long, founded on solid ledge, and built in 1861 at a cost of $5,000, backs the water a mile, and affords, with a penstock several hundred feet in length, a fall of 18 feet at high tide at the Portsmouth Company's cotton-mill. The power used is stated at 158 horse-power, which can always be obtained, no steam-power being necessary. Water always wastes during the day-time, when the large mills above are running, but during the night-time there is scarcely any waste. The power here might probably be increased to 500 or 600 horse-power at all times during working hours.

One mile above are the two dams of the Salmon Falls Manufacturing Company, at Salmon Falls, New Hampshire. The upper is of wood, 9½ feet high, and about 300 feet along, and ponds the water about 2½ miles. A canal 200 feet long, 16 feet wide, and 12 feet deep leads to mill No. 2, where the fall is 20 feet, and the power used 500 horse-power net, which can be obtained at all times. The lower dam is 9 feet high, and from it a canal 350 feet long, 16 feet wide, and 10 feet deep leads to mill No. 1, where the fall is 24 feet and the power 500 horse-power. There is said to be always a waste of water over these dams during the day-time, so that the power could perhaps be increased to some extent. No steam-power is used.

The next power is 2½ miles above and 1 mile below Great Falls. The dam is a rough stone dam, 26 feet high, and ponding the water about a mile. The fall is 30 feet, with no canal, and it is said that by carrying a canal a few hundred feet down-stream it might be increased to 34 feet. The power is owned by the Great Falls Manufacturing Company, and leased to parties running a woolen-mill, and using a small amount of power, with always a waste of water. The site is a fine one, and the power could probably be increased to about 1,000 horse-power during working hours, judging from that used at the next privilege above.

The next power is the most important one on the river, and is occupied by the Great Falls Manufacturing Company, at Great Falls, New Hampshire. There are two dams: The upper, built of cut-stone in cement, founded on ledge, and built in 1872 at a cost of $13,000, is about 6 feet high and 375 feet long. It ponds the water 2 miles, with an average width of 125 feet, and from it a rectangular canal 2,000 feet long, 36 feet wide, and 7 feet deep leads to the mills. The fall is 31 feet, and the power used is 600 horse-power at mill No. 1, and 800 horse-power at mill No. 2, besides 50 horse-power at a grist-mill and spool factory. This power, however, cannot be obtained all the time, and in mill No. 1 there is steam-power to the extent of 440 horse-power in reserve. The second dam is of rough stone without cement, with a vertical face, and is about 24 feet high and 140 feet long. It is founded on a ledge, and was rebuilt in 1845. It ponds the water nearly up to the upper dam. A canal 600 feet long, rectangular in section, 24 feet wide and 11 feet deep, carries the water to mill No. 3 and to the bleachery, the fall being 31 feet, and the power 900 horse-power at the mill and 175 at the bleachery. No steam-power is used in these mills, but full capacity can generally be obtained all the time, by drawing on the pond, so that there is no waste at all except at high water. Less than one-eighth of the basin above this point is wooded.

Two miles above Great Falls the Great Falls Company has a reservoir known as Mast Point pond, formed by damming the main stream by a wooden dam 7 feet high, which ponds the water about 4 miles, with an average width of perhaps 100 feet. It is not used for power, but for regulating the flow, and holds one day's storage. The water can be entirely drawn out, and the gates are shut every night and opened every morning, so that no water is wasted during the night.

Two miles below East Rochester there is a fall not used, known as Stair's falls, but since the construction of the Mast Point dam it is said that the fall is small, not over 5 feet.

At East Rochester is the next improved power on the river, that of the Cocheco Woolen Manufacturing Company. The dam is of wood, 10½ feet high, founded on ledge, ponding the water only about 1,400 feet, to the dam above. The fall used is 10½ feet at mill No. 3, situated at the dam, and using 50 horse-power, while at mills No. 1 and No. 2, to which the water is led by a canal 700 feet long and 20 feet wide, the fall is 16½ feet and the power some 150 (?) horse-power. Full capacity can be secured at all times excepting sometimes on Saturday, when the Great Falls Company shut the reservoirs above, in which case mill No. 3 is run by steam. Water generally runs over the dam day and night.

At the head of the pond last mentioned is a second privilege owned by the same company, with a wooden dam 8 feet high, ponding the water 2 miles, and affording power for a saw- and grist-mill, with a fall of 8 feet. The further development of this power is talked of.

A short distance above this privilege is the site of a woolen-mill which was burned in 1882. The fall was 8 feet, with a canal a third of a mile long.

The next power is a saw- and grist-mill, 1½ mile below Milton, the fall being 11 feet, with a dam 8 feet high. Between this power and the one below there is said to be a small fall once used, but now idle. It is probably of no importance.

Between the last power and Milton Three ponds is the largest fall on the river, amounting probably to not less than 120 feet in 1½ mile, and some 200 feet in 3 miles.[a] The fall is continuous, over ledges of solid rock, the banks being also very rocky and sometimes steep. This entire fall is controlled by the Great Falls Manufacturing Company, and is only utilized by a small mill at the outlet of the ponds. Of this large fall a considerable portion could be utilized, though it is impossible to say how much. As regards building dams, no difficulty would be experienced, but it might sometimes be difficult to find good locations for mills and canals, on account of the roughness of the banks. At the "flume" there is a fall of about 15 feet in 100 feet, the width of the stream being very small; and above it there is an equal fall in as short a distance. A short distance above, the Great Falls company has erected a dam and a mill, the dam being of wood, about 16 feet high, and only about 30 or 40 feet long, between cliffs of rock. The mill has never been used, and no wheel has been put in. The fall is 16 feet. Above the dam there is a fall of 15 feet, or thereabout, to the foot of the dam at the outlet of the ponds, which is 16 feet high. The fall here is used by a small excelsior-mill a short distance below the dam, using a fall of 14 feet when the ponds are full, with about 25 horse-power, and only running about ten months.

Any estimate of the power available at this place is very uncertain, because it depends entirely upon the manner in which the reservoirs are operated by the Great Falls Company. To judge from the amount of power used below, I should say that a power of 12 horse-power per foot fall could be depended upon at all times, if it could be all used during working hours. The reservoirs, however, are often closed on Saturday, so that they may partly fill up, and the supply is drawn from Mast Point pond during that day, the reservoirs being opened again on Monday morning. If mills should be located, therefore, on this fall, they might not be able to run on Saturday, while at other times the supply of water would be excessive. Similar disadvantages are always experienced by mills located near reservoirs which are controlled in the interest of mills situated far below. Not only would there probably be a lack of water on Saturday, but during other days there would always be a waste at night, for while the ponds are open they are allowed to flow night and day; and as there are no facilities for storing water at night within the distance occupied by the fall referred to, there would be no possibility of concentrating the power into working hours. These or similar considerations have perhaps been those which have prevented the utilization of the power, which is favorably situated, within easy reach of the railroad, and with building materials close at hand.

The next power above Milton Three ponds is at Milton mills, where there are several dams, and above which the fall is rapid all the way to the source of the river. The lowest dam is owned by the Waumbeck Manufacturing Company, and the power is leased, being used by a woolen-mill and a felt-mill, one with a fall of 8 feet and 36 horse-power, and the other with a fall of 10 feet and 60 horse-power. Full capacity can only be obtained during about nine or ten months, as the water is drawn from Great East pond in such a way as to cause a lack of water during a few months. The next dam is that supplying the woolen-mill of the Waumbeck Company. It is 14 feet high, the fall is 14 feet, and the power 75 horse-power, steam-power being in reserve. The next dam is of stone, 15 feet high, with flash-boards, and supplies Buffum's felt-mill, the fall being 15 feet and the power being 60 horse-power, steam-power being in reserve to the same extent. Above this is a reservoir belonging to the Waumbeck Company, the dam (called the Hooper dam) being of stone and from 15 to 18 feet high. The reservoir holds about

[a] *Geology of New Hampshire,* Vol. III, p. 150.

one day's supply. The next above is an unutilized privilege, called the "Jewett" privilege, once used by a small mill. The fall was about 12 feet, but it is said that 18 feet or more could be obtained. Above it is a second reservoir of the Waumbeck Company, the dam being of stone, 8 feet high, and the pond (known as Roe pond) holding about twenty-four hours' storage. Above it are some saw-mills, one at the dam at the outlet of Horn pond. There is no fall not utilized on this part of the stream, excepting that at the Jewett privilege. The mills, however, are obliged to have steam-power in reserve, on account of the intermittent flow from the reservoirs.

The tributaries of the Salmon Falls river are not of much consequence. Of those from New Hampshire the only one to be mentioned is Branch river, which rises in Cook's pond and empties into Three Ponds. At Union Village there are four mills on this stream running all the year. Of the tributaries from Maine the only one to be mentioned is Great Works river, which empties just below South Berwick, at the head of tide-water. It is a small stream, draining only about 92 square miles, and its flow is not very constant. It has one artificial reservoir, known as Bonny Bigg pond, covering about 500 acres—according to Wells, 1,600 acres—from which 8 or 10 feet may be drawn. At the mouth of the river is a saw- and grist-mill, with a dam 12 feet high, using a fall of 14 feet. The power available is probably about 65 horse-power net at its minimum during eleven hours. Less than a mile above this site there was formerly a dam, with a fall of about 18 feet, the privilege being now idle. It belongs to the Newichawanick Company, which owns the mills just above, and it would probably afford a power of 80 horse-power net during working hours, when the flow is at its minimum, and considerably more during the greater part of the year. Just above, or about a mile above the mouth of the stream, at Newichawanick falls, are the two dams of the Newichawanick Company, one 22 feet high, affording a fall of 29 feet, with 90 horse-power all the time, and the other 13 feet high, affording a fall of 17 feet, with 80 horse-power. These powers are excellent in almost every respect, and are in close proximity to several railroads. The gross power available during the low season of dry years is probably not less than 7 or 8 horse-power per foot fall, and during ordinary years 10 or over. During nine months probably twice as much could be utilized. Above this there are no powers worth describing.

The following tables give the power utilized on the coast streams of New Hampshire, compiled from the returns, and the drainage areas of the principal streams:

Table of drainage areas of the coast streams of New Hampshire.

Stream.	Tributary to what.	Above what point.	Drainage area.
			Sq. miles.
Exeter river	Great bay	Exeter	113
Lamprey river	....do	Newmarket	210
Oyster river	....do	Mouth	20
Bellamy river	....do	....do	30
Cocheco river	Piscataqua river	Dover	183
Do	....do	Gonic	90
Do	....do	Rochester	72
Salmon Falls river	....do	Berwick	242
Do	....do	Salmon Falls	240
Do	....do	Great Falls	231
Do	....do	East Rochester	140
Do	....do	Milton Three ponds	123
Do	....do	Milton mills	34
Little river	Salmon Falls river	Mouth	60
Great Works river	....do	....do	92
Salmon Falls river	Piscataqua river	Berwick	*a* 123
Do	....do	....do	*b* 119

a In Maine. *b* In New Hampshire.

Table of powers utilized on the coast streams of New Hampshire.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall.	Total horse-power used, net.
						Feet.	
Exeter river	Great bay	New Hampshire	Rockingham	Cotton	1	17–21	250
Do	do	do	do	Flour and grist	2	15	105
Do	do	do	do	Saw	5	46	104
Tributaries of the	Exeter river	do	do	Boxes	3	24	50
Do	do	do	do	Carriage materials	1	10	42
Do	do	do	do	Flour and grist	3	27	56
Do	do	do	do	Saw	21	190+	562
Do	do	do	do	Paper	1	9	200
Lamprey river	Great bay	do	do	Cotton	1	22–26	400
Do	do	do	do	Woolen	1	10	25
Do	do	do	do	Box	1	9	30
Do	do	do	do	Flour and grist	4	43	149
Do	do	do	do	Saw	9	106	226
Do	do	do	Strafford	Flour and grist	1	12	75
Do	do	do	do	Saw	1	12	35
Do	do	do	do	Tannery	1	10	12
Do	do	do	do	Paper	1	10	70
Tributaries of the	Lamprey river	do	Rockingham	Hosiery	1	6	25
Do	do	do	do	Cotton	1	14	45
Do	do	do	do	Box	2	17	45
Do	do	do	do	Bolts, nuts, etc	1	14	24
Do	do	do	do	Flour and grist	3	33	128
Do	do	do	do	Saw	10	86	253
Do	do	do	do	Wheelwrighting	1	5	5
Do	do	do	Strafford	Flour and grist	1	11	25
Bellamy river	Great bay	do	do	Woolen	1	44	180
Do	do	do	do	Flour and grist	1	......	......
Cocheco river	Piscataqua river	do	do	Cotton	1	30	1,000
Do	do	do	do	Woolen	2	50	455
Do	do	do	do	Saw	3	52	105
Do	do	do	do	Flour and grist	2	18	46
Tributaries of the	Cocheco river	do	do	Cutlery	1	25	27
Do	do	do	do	Woolen	1	8	35
Do	do	do	do	Blacksmithing	1	9	4
Do	do	do	do	Saw	6	77	306
Do	do	do	Rockingham	do	1	12	12
Salmon Falls river	Piscataqua river	do	Strafford	Boxes	1	11	10
Do	do	do	do	Flour and grist	2	33	100
Do	do	do	do	Saw	1	10	15
Do	do	do	do	Cotton	2	106	3,475
Do	do	do	do	Woolen	1	18	100
Do	do	do	do	Felt	1		
Do	do	do	do	Woolen	3	60	335
Do	do	Maine	York	do	1	7	12
Do	do	do	do	Cotton	1	18–20	160
Do	do	do	do	Felt	1	15	60
Do	do	do	do	Excelsior	1	14	25
Do	do	do	do	Saw	1	12	25
Do	do	New Hampshire	Carroll	Excelsior	1	11	20
Do	do	do	do	Furniture	1	13	25
Do	do	do	do	Saw	6	60	136
Tributaries of the	do	do	Strafford	do	2	19	62
Do	do	do	do	Flour and grist	1	18	50
Do	do	do	do	Machinery	1	30	15
Do	do	do	Carroll	Felt	1	11	60
Do	do	Maine	York	Woolen	3	69	260
Do	do	do	do	Agricultural implements	1	16	25
Do	do	do	do	Flour and grist	2	32	85
Do	do	do	do	Saw	13	140+	639
Other tributaries of the	Atlantic ocean	New Hampshire	Strafford	do	2	24	65
Do	do	do	Rockingham	Box	2	12+	44
Do	do	do	do	Tannery	1	4–6	10
Do	do	do	do	Flour and grist	7	55	161
Do	do	do	do	Saw	11	98	125
Do	do	do	do	Wheelwrighting	1	5	5
Do	do	do	do	Vinegar	1	......	4

V.—THE RIVERS OF MAINE.

The general characteristics of the streams of Maine have been described in the introduction to this report. A detailed report on their water-power was made in 1869 by Walter Wells, and was published by the state; and as time did not permit of a detailed examination of the state for the purposes of this report, the pages which follow are mainly condensed from that of Wells, the statistics being brought up to date, and measurements of the drainage basins, with other data, added. The streams will be considered in their order as we proceed along the coast from south to north.

THE PISCATAQUA RIVER.

This stream, which, with the Salmon Falls river, forms the boundary-line between Maine and New Hampshire, has already been considered, as one of the coast streams of New Hampshire, and all the powers on the Salmon Falls river have been fully described. The tributaries to that river from Maine are not of much consequence, and need no further description.

As we proceed along the coast we find a few tide-mills, and in the town of York, the outlet of Chase's pond, which covers 350 acres, has a rapid fall, and runs two mills, with falls of 19 and 35 feet respectively; but the power is small and not reliable all the year.

THE MOUSAM RIVER.

The Mousam river takes its rise near the middle of York county, and pursues a southeasterly course to the sea, its length being about 30 miles in a straight line, and its drainage area measuring about 157 square miles. Its basin is level or gently undulating, the soil sand, gravel, and loam, the rock granite, and the forests are mostly removed. The fall of the stream is quite large, probably in the neighborhood of 10 feet per mile. The rainfall is about 44 inches—11 in spring and in summer, 12 in autumn, and 10 in winter. The flow of the stream is said to be quite constant. The following lakes and ponds are connected with the river: Shaker's pond, 250 acres, with a storage of 2 feet; Bunganut pond, 320 acres, with a storage of several feet; Mousam pond, 1,760 acres, with a storage of several feet; Square pond, 640 acres; and Loon pond, 130 acres. These ponds suffice to regulate the flow to a considerable extent. In the absence of gaugings I have roughly estimated the flow and power of the Mousam at Kennebunk about as follows:

Estimate of flow of the Mousam river at Kennebunk.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) continuously.	
	Sq miles.	*Cubic feet.*	*1 foot fall.*	*40 feet fall.*
Minimum	150	26	3	120
Minimum low season		31	3.5	140
Maximum, with storage		100	11.4	456
Low season, dry years		35	4	160

Could the flow be controlled and confined to working hours the above powers would be about doubled.

The Mousam river is crossed at Kennebunk and at Springvale by railroads, so that every part is quite easily accessible.

As the stream is ascended, the first power is at the head of tide and 2½ miles from the sea. The total fall is 40 feet, in three pitches, only a portion being utilized, and the total power used being probably in the neighborhood of 350 horse-power. That available is estimated in the above table, and could probably be increased in this case. Two miles above are Lord's cotton-mills, with 11 feet fall and 75 horse-power; a mile above is a saw-mill with 9 or 10 feet; then Varney's falls, with 12 feet; then Great Falls, fall 45 feet, making a total fall of about 118 feet in Kennebunk. In the town of Sanford, Wells mentions sixteen powers on the river, with a total fall of about 200 feet, and in the towns above the slope is probably even larger. The table of power utilized shows that the total fall used on the river is not over 186 feet, and probably much less, because in the table the fall at each mill is counted, whether several are run from the same dam or not. There must be, therefore, a large amount of fall and of power still unutilized on the stream. The bed and the banks are said to be everywhere favorable, and the facilities for storage good. No accurate data are at hand regarding the tributaries of the stream, but they afford good and, in some cases, very constant powers.

The Kennebunk river, which empties into the ocean very near the mouth of the Mousam, is a small stream, draining about 50 square miles. It is fed by Kennebunk pond, covering about 540 acres, and capable of being drawn down 4 feet, and by Swan pond, covering about 480 acres. The stream affords a few small powers.

Fig. 19. MAP OF THE DRAINAGE BASIN OF THE SACO RIVER.

THE SACO RIVER.

The Saco river has its source in a small pond lying 1,300 feet southeast of the Crawford house, in the White mountains, New Hampshire, at an elevation of 1,880 feet above the sea. From this point the stream flows in a general southeasterly direction, crossing the state line and passing into Maine at a distance of about 34 miles from its source, measured along its course. In Maine its general course is southeast, first in Cumberland county, and in its lower part forming the boundary between Cumberland and York counties, and its length in the state is about 70 miles, following its course. The total area drained by the river is about 1,750 square miles, of which nearly exactly half is in Maine and half in New Hampshire. From its source the stream falls very rapidly for a few miles, following for 11 miles a narrow valley, with high hills on each side, extending to the water's edge. Below this point it flows through intervales, and is bordered on each side by alluvial lands, many of which are sometimes overflowed. The following table shows its slope:

Table of declivity of the Saco river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Source of river	104	1,880			
			12.5	1,135	90.8
Western boundary of Bartlett	91.5	745			
			6.5	185	28.4
Mouth of Rocky branch	85	560			
			2	49	24.5
Mouth of Ellis river	83	511			
Portsmouth, Great Falls, and Conway Railroad crossing	78	446			
			38	168	4.42
Railroad crossing, Conway Centre	73	412			
Head of Great falls	45	343			
			0.3±	72	240
Foot of Great falls	44.7	271			
Mouth of Ossipee river	40	266			
			40	266	6.65
Mouth	0	0			

Its bed is rocky almost everywhere, the prevailing rocks being granite and gneiss. The rainfall is about the same as on the Mousam. The flow is very variable, on account of the large proportion of mountain country drained by the stream and the small size of the lakes. Especially in the upper or mountainous part is this the case, the stream diminishing to almost a mere rivulet in summer, and being heavily swollen in the spring. The number of lakes in the basin, in Maine, is 75, while in New Hampshire there are about 34. None of them, however, are very large. Those in Maine have a total area of 55 square miles, and those in New Hampshire 29 square miles, making 84 square miles in all, or about 1 square mile to each 21 square miles of basin. Many of these ponds are dammed, and some are used only for regulating, while in the case of many of them additional storage is feasible. The storage facilities in the basin, in a word, may be said to be excellent, though at present not made use of to a very great extent. No accurate data regarding the flow are at hand, but the range of water, between high and low water, seldom exceeds 14 feet at any point, so that the flow is evidently much more constant than that of most streams in the southern and western states. The river is quite easily accessible by rail, being followed for almost its whole length by the Portland and Ogdensburg railroad.

As the stream is ascended, the first power met with is at the head of tide, at Biddeford and Saco, about 4 miles from the mouth. Vessels drawing 11 feet can come up to the foot of the falls, and the river is open to navigation for eight or nine months of the year, rendering transportation by sea easy. The fall is about 40 feet at low tide, the bed is solid trap-rock, and the banks were originally very rough, rugged, and high, but have been cut down as the manufactures have developed. The power has been used since 1750, but until about 1830 only for saw-mills. At present the upper dam, with a fall of 6½ feet, is only used for a saw-mill, but the lower fall of 32 or 33 feet is used by three cotton-manufacturing corporations and a grist-mill. The river is here divided into two arms, both of which are dammed. The York Manufacturing Company, situated on the island between the arms, uses a fall varying with the tide from 30 to 34 feet, while on the south bank the Pepperell Manufacturing Company uses a fall of about 16 feet, and below it the Laconia Manufacturing Company uses the remainder of the fall to tide, or about 16 feet, with a second dam. The upper of these two dams is partly of wood and partly of stone, about 335 feet long, and from 3 to 16 feet high, with 1 foot of flash-boards. The lower one, south of the island, is of stone, about 200 feet long, and from 3 to 7 feet high. The power is owned by the Saco Water-Power Company, controlled by the Pepperell and Laconia Manufacturing Companies, and the low-water flow is completely utilized. The York Company owns the right to 11 mill-powers, a mill-power being defined as the right to draw 25 cubic feet of water per second on a fall of 30 feet. Increase in quantity is allowed as the fall becomes less than 30 feet; if it

is over 30 feet, the mills obtain the benefit of it, the quantity being undiminished. With a fall of 30 feet a quantity of water equal to 25 cubic feet per second affords a gross power of 85.23 horse-power, as at Lowell, so that the York Company owns 937 gross horse-power. The remainder of the flow, or all in excess of the 11 mill-powers reserved for the York Company, and which can be obtained at all times, is owned by the Pepperell and Laconia companies, in the proportion of $\frac{4}{7}$ to the former and $\frac{3}{7}$ to the latter. The Pepperell Company uses at times water-power to the extent of 2,000 horse-power, but can only obtain it during about eight months, being sometimes unable to obtain over 300 or 400 horse-power; and it has steam-power to the extent of 1,500 horse-power. The Laconia Company can use all the water passing the wheels of the Pepperell Company, together with what goes over the dam, but only uses about 1,600 horse-power, and in dry weather is limited, like the Pepperell, to 300 or 400. It has steam-power equal to 1,000 horse-power. The York Company uses 1,100 or 1,200 horse-power when running all its wheels at full capacity, but generally limits the water-power used, to the 11 mill-powers using steam-power, to the extent of 400 horse-power continually. Surplus power may be used if desired, the price charged being $3 per mill-power per day for every mill-power above the 11 mill-powers owned. Measurements of the quantity of water used by the York Company are made by the Water-Power Company, by observing daily the height of water in penstock and wheel-pit, and the height of gate, thence determining, by means of wheel-tables or diagrams, the quantity used. Flume measurements are also made at intervals, to determine whether any change has occurred in the running of the wheels. No measurements are made of the quantity used by the Laconia Company. On the other arm of the river the lower fall is used by a grist-mill, the power being small.

The York Company uses continuously, for eleven hours every day, a quantity of water equal to 275 cubic feet per second. The minimum quantity used by the Pepperell Company is perhaps 200 cubic feet per second; making in all, on both sides of the river, during working hours, say, 500 cubic feet per second. The ponds of the dams at Saco are of small capacity, but those farther up the stream, and which will soon be referred to, are sufficient to control the flow, rendering it possible to save the whole of it in a dry time. During eight months there is a waste, but during the remaining four months there is little or no waste. The minimum flow of the stream, during twenty-four hours, is, therefore, probably not far from 250 cubic feet per second. The following estimate will give some idea of the power, and enable those farther up the stream to be judged of:

Estimate of power of the Saco river at Saco and Biddeford.

State of flow (see pages 8-10).	Drainage area.	Flow per second.	Horse-power available (gross) during twenty-four hours.		
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*32 feet fall.*	*40 feet fall.*
Minimum	1,734	250	28.4	909	1,136
Minimum low season		325	36.9	1,181	1,476
Maximum, with storage		1,000	113.6	3,635	4,544
Low season, dry years		375	42.6	1,363	1,704

The range of the water is given by Wells as from 8 to 10 feet. No trouble is experienced on account of freshets or ice.

The Saco Water-Power Company controls several reservoirs on the stream and tributaries, as follows:

1. Little Ossipee pond, in Waterborough, covering about 525 acres, and dammed to a height of 9 feet. 2. Moose pond, covering 1,648 acres, from which 8 feet may be drawn. 3. Kezar pond, 2,065 acres, with a dam 5 feet high. 4. Watchic pond, 425 acres, range, 4 feet. 5. Horn pond, 150 acres; range, 7 feet. 6. Great Ossipee pond, in New Hampshire, 3,809 acres; range of 3 feet controlled. 7. Silver lake, about 400 acres; range, 4 feet.

Other ponds, not belonging to the company, are dammed and contribute to render the flow constant. According to Wells, nine ponds connected with the Little Ossipee river, a tributary of the Saco, aggregate 8.3 square miles in area; twelve ponds connected with Great Ossipee river aggregate 15.25 square miles; and twenty or more other ponds connected with the Saco aggregate 24.25 square miles. Many of the above are dammed, and others easily could be.

Above Saco the next power is at Union falls, 12 miles distant by the river. It is owned by the Saco Water-Power Company, which built a stone dam there in 1856, and uses it simply as a reservoir. The fall is 15 feet, and is entirely unoccupied. The gates are shut every night to save the water. The drainage area above measures about 1,677 square miles, and the minimum power during twenty-four hours would probably be not less than 400 horse-power on a fall of 15 feet. In the low season of ordinary years the power would probably be about 750 horse-power on the same fall. Below the dam the fall continues for half a mile, the fall in that distance being 8 or 9 feet. The pond is about 2 miles long, at the head of which is Salmon Falls, the next power. A wooden dam 20 feet high once stood here, but has been destroyed, and no power is now utilized. The fall is 62 feet in about 3,500 feet, over a narrow bed of solid rock. I should roughly estimate the power about as follows:

Estimate of power at Salmon Falls.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) during twenty-four hours.		
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	*62 feet fall.*
Minimum	1,628	235	26.7	534	1,655
Minimum low season		300	34.1	682	2,114
Maximum, with storage		975	110.8	2,216	6,870
Low season, dry years		340	38.6	772	2,393

The facilities for the utilization of this power are said to be excellent, and a large supply of good granite is within 2 miles. The falls are 15 miles from Portland, and within 1¼ mile of the Portland and Rochester railroad.

The next power is at Bar Mills falls, 1⅓ mile by the river above the last power, where the fall is 18 feet in 1,000 feet, of which about 12 feet are used by saw-mills. The available power per foot fall is about the same as at the falls below, for which see the previous table. The facilities for utilization are good and the location is excellent. The railroad crosses the river near the falls, which are 15 miles from Portland and 10 miles from Saco.

Five miles up the river is the next site, Moderation falls, at West Buxton village. The fall is 14 feet in 600 feet, the bed being rock and the banks very favorable. The power is partially improved, and is used by two woolen factories and some other mills. I estimate the power available about as follows:

Estimate of power at Moderation and Bonny Eagle falls.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) during twenty-four hours.		
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*14 feet fall.*	*48 feet fall.*
Minimum	1,578	225	25.6	358	1,229
Minimum low season		290	33.0	462	1,584
Maximum, with storage		950	108.0	1,512	5,184
Low season, dry years		325	37.0	518	1,776

These falls are 18 miles from Portland, 14 miles from Saco, and 5 miles from the nearest station on the Portland and Ogdensburg railroad.

The next power is 1¼ mile above, at Bonny Eagle falls. The fall here is 48½ feet in a distance of half a mile, and 25 feet within 800 feet. "The water of the river divides at the head of the falls, and runs in two channels to the foot of the falls, forming an island containing about 60 acres. By the main or western channel the water descends through a narrow passage bounded by rocks, in a succession of falls and rapids, while by the other or eastern channel the descent, though rapid, is continuous." The banks are favorable for the construction of canals and mills, and the power is partially improved by saw-mills. That available is estimated in the previous table. These falls are 6 miles from the nearest railroad station.

The next power is about 5 miles above, and known as Limington falls. The fall is 65 feet in about 1,800 feet, and the width of the stream 250 feet. The falls are partially improved. One mile above are Union falls, 26 feet in a quarter of a mile. Just above are the Steep falls, 40 feet in three-quarters of a mile, partially improved. At these three falls, which naturally belong together, we may estimate the power about as follows:

Estimate of power at Steep falls.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross) during twenty-four hours.				
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*65 feet fall.*	*26 feet fall.*	*40 feet fall.*	*15 feet fall.*
Minimum	1,375	206	23.4	1,520	608	936	351
Minimum low season		264	30.0	1,950	780	1,200	450
Maximum, with storage		825	93.7	6,090	2,436	3,748	1,405
Low season, dry years		300	34.1	2,216	887	1,364	511

Four miles above are Highland rips, 15 feet fall in 40 rods. This site was unimproved at the time of Wells report. The power may be estimated by comparing with the above table, as the quantity of water is about the same. The next large power is in Hiram and Baldwin, where there is a heavy fall. Two and a half miles below Hiram bridge are the Great falls, where the total fall is 72 feet in 55 rods, the bed and banks being solid rock The facilities for utilization are said to be good. The falls are above the mouth of the Great Ossipee river, and the flow is consequently more variable than below. Above the falls the country is flat, and a very large reservoir could easily be formed, for a dam 6 feet high at the head of the falls would, it is said, deaden the current for nearly 15

miles. There are also 15 or 20 square miles of lake or swamp surface above this point, which could, if desired, be used as reservoirs to a much greater extent than they now are. The falls belong to the Saco Water-Power Company, and are unimproved. The available power may be estimated about as follows:

Estimate of power at Great Falls.

State of flow (see pages 8-10).	Drainage area.	Flow per second.	Horse-power available (gross) during twenty-four hours.	
	Sq. miles	*Cubic feet.*	*1 foot fall.*	*72 feet fall.*
Minimum	856	100	11.3	814
Minimum low season		120	13.6	979
Maximum, with storage		440	50.0	3,600
Low season, dry years		135	15.3	1,100

Half a mile below the foot of Great falls is a fall known as "Great Falls' Wife", amounting to 8 or 10 feet in half a mile, and unimproved.

The next power is Swan's falls, in Fryeburg, with a fall of 8 feet. Above this point, in its course through New Hampshire, the Saco is a rapid mountain stream, flowing over a rocky or gravelly bed, bordered in places by extensive alluvial lands. Numerous sites for power could be found, but the chief objection to the use of power is the very variable flow of the river, which is a torrent at times, and at times a mere brook. It supplies no power in this part of its course.

The first important tributary of the Saco river is the Little Ossipee, which enters between Bonny Eagle and Limington falls. Some tributaries below have large falls and run small powers, but are not permanent. Little Ossipee river has its source in Balch pond, partly in Maine and partly in New Hampshire, and flows in an easterly direction, draining about 158 square miles, its length being about 30 miles. It has tributary to it a number of ponds, the nine principal ones having an aggregate area of 8.3 square miles, and three of them being dammed. Considerable additional storage is feasible. The stream has a number of good sites:

1. Chase's falls, 35 feet in 40 rods, near the mouth, and partially improved.
2. Nason falls, 3 miles above, 60 feet in 1,320 feet, partly improved.
3. Some rapids in Limerick and Waterborough, partly improved. Above these are a number of falls, some utilized by mills of various kinds. The flow of the stream is quite constant, and its power excellent. Balch pond, at the head, which covers 2½ square miles, is dammed, and can be drawn down 8 feet.

The next tributary is Great Ossipee river, which has its source in Ossipee lake, in Carroll county, New Hampshire, at an elevation of 408 feet above the sea. From this lake, which covers about 3,809 acres, and is dammed to a height of 3 feet, the river flows eastward, its length being about 15 miles in a straight line, and its drainage area measuring about 470 square miles, of which about 370 square miles lie in New Hampshire. Its drainage basin is largely level and sandy, especially that part lying in New Hampshire. The total fall of the stream, however, is 142 feet, as will be seen by comparing with the table on page 71. A number of lakes, besides the one mentioned, are tributary to the river, twelve of the principal ones (including Great Ossipee) having a total area of 15.25 square miles (Wells), and seven of them being dammed to heights varying from 3 to 12 feet. The flow is consequently quite uniform, and the freshets not severe. The stream is accessible at both ends by two railroads.

Great Ossipee offers a number of good powers. Half a mile above the mouth a fall of 10 feet is available; at Warren's mill is a similar fall; between this and Kezar falls are two sites, with 12 feet each, and at Kezar falls the fall is 50 feet in a mile, partially improved. At French's falls a fall of 9 feet occurs, and at South River falls there is one of 8 feet. There are probably other available sites, but none are mentioned by Wells.

Judging from the facts at my command, I should estimate that the minimum flow of the stream at its mouth would be about 70 cubic feet per second, affording about 8 gross horse-power per foot fall. In ordinary years the flow in the dry season, however, would be much in excess of this figure.

No very important tributaries enter above the Ossipee. Some outlets of ponds in Denmark and Fryeburg afford excellent sites, with very constant power and large fall, for the details of which we must refer to Wells' report. The tributaries in New Hampshire, like the main stream, although having very large falls, are unreliable on account of their variable flow.

It is evident from the above that the Saco, in its lower parts, is a very good stream for power, offering almost every advantage that could be desired.

THE PRESUMPSCOT RIVER.

This river, which will be found to resemble in many respects the Winnipiseogee river in New Hampshire, is the outlet of Sebago lake, a beautiful sheet of water, covering an area of some 50 square miles, in Cumberland county, and lying at an elevation of 251 feet above the sea. From this lake the stream flows in a southeasterly direction, entering Casco bay about 4 miles north of Portland, its length being about 22 miles, and its drainage area measuring about 726 square miles. It receives no very important tributaries, and the principal towns it passes are Westbrook, Saccarappa, and Cumberland Mills. The fall of the stream is, according to the above, 251 feet in 22 miles, or 11.4 feet per mile. The drainage area of the lake measures about 500 square miles, and the upper part of the basin has an elevation of 800 or 900 feet, sloping gradually toward the south. The northern part is well wooded, while the southern part is mostly cleared. The bed and banks of the stream are in every way favorable for power, but its greatest advantage is its very constant flow. The following reservoirs are given by Wells as tributary to the river:

Reservoirs of the Presumpscot.

Name.	Approximate area.	Storage (1869).	Additional storage feasible.
	Sq. miles.	*Feet.*	*Feet.*
Sebago lake	50	(In 1882) 6	....
Trickey pond	0.75	....	....
Peabody pond	1.50	....	....
Brandy pond	1.25	....	....
Long pond	12	Dam	(a)
Pleasant pond	2.25	....	....
Panther's pond	2.75	....	(b)
Rattlesnake (two ponds)	2.75	....	....
Little Sebago pond	5	7	5
Crotched pond	2.75	5	2
Adams' pond	0.30	4	2
Holt's pond	0.30	Dam	....
Stearns' pond	1	....	4
Anonymous pond	0.75	Dam	....
Wood's pond	1.50	6	(c)
Thomas pond	1.15	Dam	....
Long pond, Waterford	1	....	....
Bear pond	0.75	1	4
Moose pond	0.75	....	....
Songo pond	0.85	....	....
Stone (two ponds)	1.10	....	....

a Several feet. *b* High dam feasible. *c* Outlet can be lowered 3 feet.

The total number of lakes is 45, with a total area of 97 square miles, or 1 square mile to every 7.5 square miles of basin. The 23 named above aggregate 90.45 square miles in area. No large stream that we have yet met with, except the Winnipiseogee river, has so large a proportion of its basin taken up by lake surface. The flow is therefore very constant, the extreme range of water on the dams at Westbrook being only 4 or 5 feet; and the natural constancy of the flow is much increased by the artificial storage, especially that on lake Sebago. A stone dam 20 feet high, built in 1878 and 1879, raises the level of the lake 6 feet, that depth being, therefore, under control, and the dam being used only for regulating the flow. This dam is controlled by the mill-owners below, under the name of the Presumpscot Water-Power Company. A depth of 6 feet over 50 square miles is probably sufficient to render available the maximum flow permanently possible, so that in the case of this river the "maximum with storage" is reached. Following the river downward, the powers on it are as follows:

The dam at the outlet could easily be used as a source of power, the fall varying from 20 to 14 feet. Eel Weir falls, below, have a fall of 12 feet; Hubble falls, lower down, have 8 feet; Steep falls, 12 feet; Hardon's falls, 11 feet 1 mile from the lake; Great falls, 1 mile below, 16 feet utilized; Whitney's falls, half a mile below, 14 feet; Island falls, half a mile below, 10 feet; Dundee falls, nearly a mile below, 18 feet; Leavitt's falls, nearly a mile below, 12 feet; Gambo falls, a mile below, 16 feet; Little falls, a mile below, 17 feet; Mallison falls, half a mile below, 18 feet.

Of these falls some are partially improved, but the entire power available is used in few cases, if any.

The next power is at Saccarappa, where there are two dams. The uppermost is of wood, 150 to 200 feet long and 9 feet high, ponding the water for 5 miles. The fall is 12 feet, and the power is used on both sides of the river. On one side is the Westfield Manufacturing Company's cotton-mill, with about 300 horse-power, and on the other are two cotton-mills and two saw-mills, using in all about 400 horse-power. Full capacity is always to be had. The

lower dam is of wood, about 400 feet long and 12 feet high, making a pond of only a few hundred feet. The fall is 19 feet, and on the left bank the Westfield Manufacturing Company uses 500 horse-power, while on the opposite side are a number of small mills of various kinds, using, it is said, about 800 horse-power. This power is excellent in all respects.

The next power is at Cumberland Mills, 5 miles from Portland and a mile below Saccarappa. A dam of wood and stone, 12 feet high and 250 feet long, affords a fall of 20 feet, used at the paper-mills of S. D. Warren & Co., where the power in use is 2,000 horse-power. This power can be obtained about nine months of the year, and during the rest of the time steam-power to the extent of 750 horse-power is used. In dry weather there is no waste, as the mills run night and day.

Below this power there is one other, at the head of tide, known as Presumpscot Lower falls, owned by S. D. Warren & Co., but it is not used. It is 7 or 8 miles below, and the fall is said to be about 15 feet at high tide. Formerly this site was utilized.

As regards the power available at these sites, it may be regarded as practically about the same in a dry season from the lake to the mouth of the river, for the small tributaries which come in between those points, though carrying large quantities of water at times, are in dry weather often mere brooks. The power available in a dry season is, therefore, that derived from the storage on the lake, and in estimating it we have only to consider how much water can be collected from the water-shed of the lake. The annual rainfall on this water-shed is, on the average, about 44 inches; the minimum probably about 27 inches. The observations on lake Cochituate, near Boston, show that on that water-shed about 40 per cent. of the rainfall can be collected. From the character of the drainage basin of lake Sebago I should think that about the same proportion could be collected there, so that, if this is true, the minimum quantity available during an entire year would be about 11 inches. Probably this is all that could be permanently depended upon, though for a number of years in succession a considerably greater quantity could be collected. In order to insure the uniform discharge of this quantity from the lake, the latter must be capable of storing 3 or 4 inches on the water-shed. The storage depth of 6 feet would probably be sufficient for this purpose, unless the banks are very flat. Taking, then, 11 inches as the maximum with storage, we have a discharge of 0.8 cubic foot per second per square mile, or a total discharge, uniformly through the year, of about 400 cubic feet per second. This quantity would afford a gross power of about 45 horse-power per foot fall, from which the power at the different falls can be calculated. Could the flow for twenty-four hours be discharged during the eleven working hours, the power would be increased in the proportion of 24 to 11.

It is evident from the previous pages that few streams offer the advantages for power that the Presumpscot affords. The total fall of the river being 251 feet, the total power available in its course would be 11,295 horse-power continuously, or 24,631 horse-power during eleven hours. Of this only about 6,000 horse-power are now used.

The tributaries of the river are not of much importance, but some of them are outlets of ponds and have considerable fall, thus affording excellent constant powers, though small. Others are variable in flow and of little value. Little Sebago pond is dammed, and on its outlet are several good powers. Among the tributaries of the lake, similar streams are found; but to enumerate all of them, and name the powers upon them, would require more time and space than are available. Suffice it to say, that numerous streams are found—small ones, to be sure—which afford storage facilities quite sufficient to render almost the maximum with storage available. The longest and largest tributary of the lake is Crooked river, which is "estimated to be 42 miles long", and which affords considerable power. Adding up the falls on it which are mentioned by Wells, the total is 109 feet, only part of which is used. Its most important site is near its mouth, at Edes falls, where the fall is 36 feet.

THE ANDROSCOGGIN RIVER.

The Androscoggin river has its sources partly in Maine and partly in New Hampshire. The river is entitled to its name really only southward from the confluence of the Magalloway river (which has its source in the extreme northwestern corner of Maine, almost on the New Hampshire and Canada lines), and the outlet of the range of lakes which, commencing with lake Umbagog, extends in a northeasterly direction for 30 miles in Maine. The junction of the two streams referred to is about a mile from Umbagog lake, in Coos county, New Hampshire, and from this point the Androscoggin pursues a general southerly course for about 28 miles, measured in a straight line, or 38 miles along its course, when it bends to the left, and flows nearly east for about 20 miles, entering Oxford county, Maine. It then deflects toward the north, and flows north of east for over 30 miles, when, in the southern corner of Franklin county, just above Livermore falls, it bends sharply toward the right, and for over 30 miles flows almost directly south, traversing Androscoggin county. For the rest of its course for about 24 miles it flows southeast, emptying into Merrymeeting bay, after forming for several miles the boundary between Cumberland and Sagadahoc counties. The total length of the stream proper, along its course, is probably about 160 miles, but

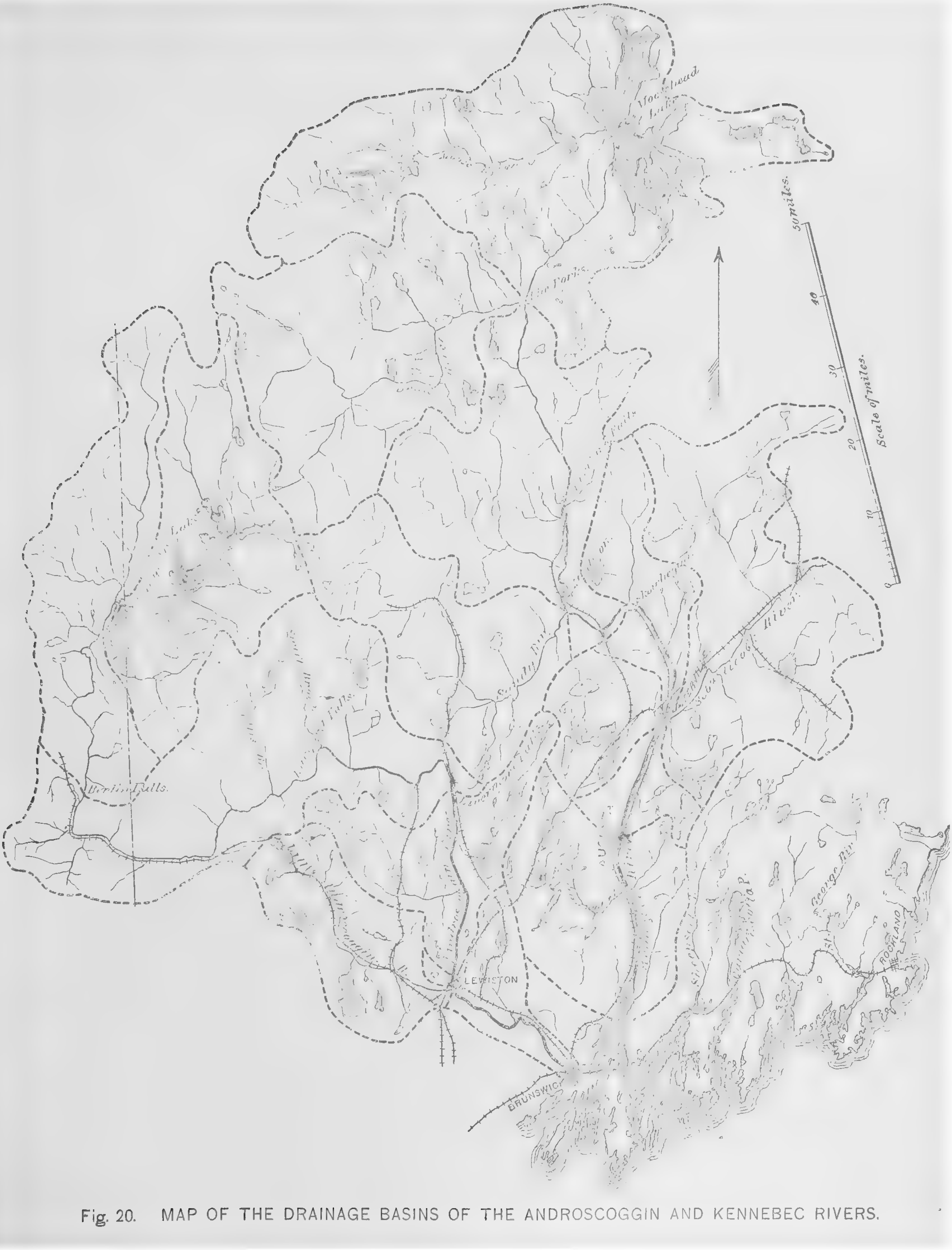

Fig. 20. MAP OF THE DRAINAGE BASINS OF THE ANDROSCOGGIN AND KENNEBEC RIVERS.

from the remotest sources of the Magalloway the distance is 200 miles. The basin is about 110 miles long, with a maximum width of 70 miles. The total area drained measures 3,698 square miles, of which 2,967 lie in Maine and 731 in New Hampshire. The principal tributaries are given in the following table:

Name of stream.	Where received.	Basin. Length. (a)	Breadth. (a)	Area.	Length of stream. (a)
		Miles.	*Miles.*	*Sq. miles.*	*Miles.*
Little Androscoggin river (from right bank)	Auburn	30	15	381	40
Twenty-Mile river (from the right bank)	Turner	19	13	189	25
Sabattus river (from the left bank)	Lisbon	16	7	100±	....
Dead river (from the left bank)	Leeds	22	5	138±	28
Webb's river (from the left bank)	Dixfield	17	11	169	23
Swift river (from the left bank)	Mexico	22	8	....	24
Ellis river (from the left bank)	Rumford	18	13	175	25
Magalloway river (headwaters)	....	37	18	416	50
Outlet of lakes	....	50	20	760	53

a Wells.

The drainage basin of the Androscoggin is, as a whole, probably more elevated than any other hydrographic basin on the Atlantic coast, the sources of the Magalloway lying at elevations of from 2,600 to 2,900 feet, while the Umbagog lakes are from 1,256 to 1,511 feet above the sea. The upper part of the basin is very broken and mountainous, and very thickly wooded. In its course in New Hampshire the stream flows almost directly toward the highest and most massive range of the White mountains, approaching within 10 miles of the summit of Mount Washington, but at Gorham this barrier turns the stream abruptly toward the east. Toward the lower part of the basin the mountainous character of the country is lost, and the forests become less extensive. The fall of the stream, however, is everywhere large, averaging for the stream proper about 7.85 feet per mile, or larger than that of any large stream on the Atlantic coast which we have yet considered. The following table shows the slope more in detail:

Slope of the Androscoggin river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0			
			75	600	8.0
Head of Rumford falls	75	600±			
			25	20	0.8
Bethel	100	620			
			14	70	5.0
State line	114	690			
			14	358	25.6
Head of Berlin falls	128	1,048			
			32	208	6.5
Head of river proper	160	1,256			
			26	344	13.2
Parmachene lake	186	1,600			
			13	625	48.1
Magalloway lake	199	2,225			

The bed of the river, like that of all the streams on the southern slope of Maine, is generally rock at the places where falls occur. The banks are generally high, there being few low grounds subject to inundation. The intervales are narrow. The flow of the stream is quite variable, on account of the mountainous character of the upper two-thirds of the basin, but the great reservoirs connected with it have of late years been considerably improved, and its flow therefore rendered much more constant than it formerly was. The extreme range from high to low water is 10 feet at Brunswick, 8 feet at Lewiston, 20 at Rumford falls, and 28 at Bethel, showing clearly the increasing variability toward the mountain region.

The number of lakes in the basin is 148, of which 133 are in Maine and 15 in New Hampshire. The following tables have been copied from Wells' report, and the numbers have been liable to change since that report was written:

Principal reservoirs of the Androscoggin river and its tributaries.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Taylor pond	Little Androscoggin river.	2.00	4	
Upper Range pond	...do	0.85	4	
Middle Range pond	...do	0.55	4	
Lower Range pond	...do	0.50	4	
Tripp pond	...do	1.25	No dam.	4
Thompson pond	...do	8.00	6	
Hogan and Green ponds	...do	1.40	Dam	
Saturday pond	...do	0.75	9	
Moose pond	...do	0.80	No dam.	10
Matthews pond	...do	0.25		
Great Pennessewassa pond	...do	2.50	12	
North pond	...do	0.30		15
Little Pennessewassa pond	...do	0.30	No dam.	10
Sand pond	...do	0.30	15	
Moose (Paris) pond	...do	0.35	No dam.	(*a*)
Mud and Hicks ponds	...do	0.55	...do	(*a*)
Bryant's pond	...do	0.60	Dam	(?)
Indian pond	...do	0.30	...do	
Twitchell pond	...do	0.35	...do	
Twenty-one ponds		21.90		
Pleasant pond	Twenty-Mile river	0.60		
Brettun's pond	...do	0.30	Dam	
Bear pond	...do	1.05	...do	
South pond	...do	0.55		
North pond	...do	0.75		
Bungermuck pond	...do	0.80	8	
Labrador (two) ponds	...do	0.35	4	(?)
Pleasant (Sumner) pond	...do	0.25	3	
Nine ponds		4.65		
Androscoggin pond	Dead river	5.75		*b* 6
Wing's pond	...do	1.00	6 to 8	*c* 2 to 4
Lovejoy's pond	...do	1.00	6 to 8	*c* 2 to 4
Pond above Lovejoy's	...do	0.20	6 to 8	*c* 2 to 4
Crotched pond	...do	2.25	4	*a* 2 to 4
Parker's pond	...do	3.10	3	4
David's pond	...do	0.80	Dam	
Tilton's pond	...do	0.25		
Flying pond	Dead river	1.25	8	
Kimball's pond	...do	0.25		
Mount Vernon pond	...do	0.35	Dam	(*a*)
Eleven ponds		16.20		
Webb's pond	Webb's river	3.00		9
Swift River ponds (three)	Swift river	2.25		
Ellis pond	Ellis river	1.25	Dam	
Little Ellis pond	...do	0.85	...do	
Six ponds		7.35		
Sabattus pond	Androscoggin river	4.00	Dam	
Wilson pond	...do	3.00	8	2 or 3
Little Wilson pond	...do	0.20	Dam	
Bates pond	...do	0.30		
Long pond	...do	0.35	4 to 5	2
Round pond	...do	0.25	4 to 5	2
Moosehill pond	...do	0.25		
Whitney pond	...do	1.00	Dam	(?)
Forest pond	...do	0.25	...do	
Worthley pond	...do	2.00	3	5
Concord (two) ponds	...do	0.65		(*a*)
North pond	...do	0.85		4
South pond	...do	0.80		
Burnside pond	...do	1.50		
Umbagog lake	...do	18.00	14	
Welokenebacook lake and the pond below.	...do	11.15	20½	
Molechunkemunk lake	...do	10.00 } 77		
Mooselucmaguntic lake	...do	21.00	14	
Capsuptic lake	...do	3.00	14	
Rangeley lake	...do	14.00	10	
Quimby pond	...do	0.40		4
Gull (two) ponds	...do	0.80		
Long pond	...do	1.00		10
Various small ponds	...do	1.00		
Parmachene lake	Magalloway river	3.50		
John's pond	Kennebago river	1.50		
Kennebago pond	...do	4.00		(*a*)
Thirty-six ponds		105.85		

a Several feet. *b* With large damage. *c* By cutting down outlet.

The foregoing 83 principal ponds cover 156.25 square miles, but the aggregate number of lakes is 148, and the area of lake surface is about 213 square miles, or one-seventeenth of the area of the basin.

No detailed data are at hand regarding the various reservoirs, except for the large lakes at the head of the river. The following table is from Wells' report:

Name.	Distance from the preceding lake.	Height above tide.	Difference of level.
	Miles.	*Feet.*	*Feet.*
Umbagog		1,256	
Richardson (*a*)	5	1,456	200
Mooselucmaguntic	1	1,486	30
Rangeley	2	1,511	25

a Molechunkemunk and Welokenebacook are sometimes classed together as Richardson lake.

These lakes have long been used for log-driving, but the storage on them is now controlled by the Union Water-Power Company, of Lewiston. The upper dam, between Rangeley and the lake below, was built in 1881, and is known as the "Rangeley" dam. It is 10 feet high, and 10 feet can be drawn from the lake. The next dam,

known as the "upper" dam, is below Mooselucmaguntic lake, and was built 20 years ago, or thereabout. It is 1,435 feet long and about 20 feet high, controlling 14 feet on the lake. The next dam is just above Umbagog lake, and is known as the "middle" dam. It was built about the year 1879, and is 600 or 700 feet long. It is said to control a depth of 20½ feet over the lake. The lowest dam is at Errol, New Hampshire, below the mouth of the Magalloway, and is 14 feet high, controlling that depth on lake Umbagog. No power is used at these dams except a small saw-mill at the upper dam, and a grist- and saw-mill at the Errol dam. The drainage area of the outlet stream from these lakes measures about 760 square miles. It seems probable that the capacity of the lakes is more than sufficient to render available the maximum with storage over this area, and it is clear that they are of immense benefit to all the mills below. Assuming that they render available the maximum with storage over their drainage basin, and taking this as corresponding to 15 inches of rainfall, on account of the dense forests with which they are encircled, they would allow of the uniform discharge, throughout the year, of 836 cubic feet per second, a quantity which would afford, taking account of losses by evaporation, on the total fall of 1,256 feet to tide-water, a gross power of 107,000 horse-power, and at Lewiston alone over 4,000 horse-power. These figures might be varied greatly according to the manner of controlling the flow. The facilities, then, for storage in the basin of the Androscoggin are exceptionally fine, and the effect of the reservoirs is to offset to a great extent that of the mountainous character of the country.

The mean annual rainfall over the basin is about 46 inches, of which 11 fall in spring, 11 in summer, 14 in autumn, and 10 in winter. This distribution is in itself favorable to constancy of flow, and unfavorable to a large discharge, but it is evident that in view of the dense forests covering the upper part of the basin, and its very mountainous character, a larger proportion than usual—I should think 50 per cent. or over—will nevertheless be discharged by the stream. The estimates given beyond may seem high to some, but they may be explained by these remarks.

The Androscoggin is quite easily accessible at most points, being followed, as the map shows, by various railroads.

From its mouth to the foot of the falls at Brunswick, a distance of 6 miles, the river is tidal and navigable, the rise of the tide at that point being 2½ feet, and the navigable depth at high water 5½ feet. At Brunswick there are two dams. The upper is principally of wood, but partly formed of the natural rock, and is 15 feet high, ponding the water about 700 feet. The fall is 16 feet, used only on the Brunswick side by the Cabot Manufacturing Company's cotton-mill, with 800 horse-power. Full capacity can always be obtained, and there is always a waste. The lower dam, a few rods below, is also about 15 feet high, and power is used on both sides, the fall varying with the tide from about 11 to 14 feet. On the left bank (in Topsham) the Bowdoin Paper Manufacturing Company uses perhaps 750 horse-power, and a small amount of power is used by a grist-mill, a saw-mill, and a sash, door, and blind factory. The method of distributing and owning the power is crude and indefinite. There is sometimes a lack of full capacity, on account of the water being held back by the mills above Brunswick, and during three months of the year there is no waste in the day-time, except what leaks through the dam, which is old and defective. On the Brunswick side are the Androscoggin Pulp Company, two saw-mills, a box-mill, and a grist-mill. Full capacity is obtained during about nine months. During the rest of the year there is lack of water during the day-time, but excess at night.

The falls at Brunswick are known as the "Pejepscot" falls, and include, besides the two pitches just described, a third, about 2,000 feet above the lower one, the fall there being between 11 and 12 feet, once used by saw-mills, but now unutilized. The total fall is therefore about 40 feet. Wells states that by raising a dam at the upper falls, which could be done without causing much flowage, the fall at the upper site could be increased to 25 feet, making the whole fall 54 or 55 feet. The amount of power available depends on how it is used at Lewiston, the next large power above. Probably the minimum flow during eleven hours, if it could be concentrated into that time, would be not less than 2,800 cubic feet per second, affording a gross power of 318 horse power per foot fall. It seems probable that during ordinary years the flow during working hours would always be as much as 3,000 cubic feet per second, equal to 410 gross horse-power per foot. The power is an excellent one in all respects, and if a large enough pond could be obtained would probably afford, on a fall of 55 feet, say, 22,000 horse-power at all times in ordinary years. Three miles above Brunswick is a site where a small fall could be used, but which may become important as a site for a dam to be used for storage. The topography at Brunswick is in every way favorable for a more extensive utilization of the power.

The next power above Brunswick is at Lisbon falls, 11 miles below Lewiston. There are two falls, the total descent being, according to Wells, 33 feet in 1,800 feet. A dam is built at the foot of the upper falls, and is 10 feet high. The fall used is 13 feet at the woolen-mill of the Worumbo Manufacturing Company, where a power of about 400 horse-power is utilized, with a waste at all times. At the lower falls there is now no dam, and no power is utilized. The topography is in every way favorable for the complete utilization of the power. The minimum power available continuously may be estimated at about 142 horse-power per foot fall, or 4,686 horse-power on a fall of 33 feet; while during ordinary years about 180 horse-power per foot fall could be obtained, or 5,940 horse-power on a fall of 33 feet. Whether a pond could be obtained sufficient to store the water at night I am unable to say. This power, with that at Brunswick, will compare favorably with any powers we have yet met with, and they deserve further examination. Excellent building materials may be obtained in close proximity to both places.

The next power is 2 miles below Lewiston falls, known as the "Lewiston Lower Power", not improved. The fall available is not stated by Wells.

The next power, and the most important one on the river, is at Lewiston, 40 miles by the river from the ocean, and just above the mouth of the Little Androscoggin. The bed is solid rock, and the natural fall is 38 feet in a distance of 600 feet, but a dam at the head of the falls, with an average height of 12 feet, makes the available fall about 50 feet. The pond is short—only about 1½ mile in length—and is not sufficient, even with those above, to store all the water at night in dry weather. Power is used on the left bank, the fall being used on two levels. The fall from the upper to the lower is about 28 feet, and is used by the following mills:

1. Lincoln mills, owned by the Franklin Company; cotton-mills; 265 cubic feet of water per second; 840 gross horse-power.
2. Bates Manufacturing Company's cotton-mill; 698 cubic feet per second; 2,160 gross horse-power.
3. Hill Manufacturing Company's cotton-mill; 544 cubic feet per second; 1,685 gross horse-power.
4. Saw-mill; 27 feet fall; 50 horse-power.

In addition, the following two mills take water from the upper level, but do not discharge into the lower level:

5. Androscoggin cotton-mills; 37 feet fall; 387 cubic feet per second; 1,628 gross horse-power.
6. Lewiston bleachery and dye-works; 34.74 feet fall; 131 cubic feet per second; 516 gross horse-power.

The water from 5 and 6 is used by the following two:

7. Androscoggin cotton-mill (lower mill); 12.50 feet fall, 483 cubic feet per second; 686 gross horse-power.
8. Cumberland woolen-mill; 12.50 feet fall; 40 (?) cubic feet per second; 57 gross horse-power.

The fall from the lower level to the river is about 22 feet, and is used by the following mills:

9. Lewiston cotton-mills; 20.9 feet fall; 445 cubic feet per second; 1,059 gross horse-power.
10. Continental cotton-mills; 21.77 feet fall; 951 cubic feet per second; 2,353 gross horse-power.

These last mills, however, do not receive the water from the Lincoln mill, which goes directly to the following:

11. Home Manufacturing Company's woolen-mill; 17.7 feet fall; 90 cubic feet per second; 181 gross horse-power.
12. D. Cowan & Co.'s woolen-mill; 18.4 feet fall; 95 cubic feet per second; 199 gross horse-power.

There is also, on the lower level, a mill belonging to the water power company, in which small amounts of power are leased, nominally at so much per horse-power, but no measurements of quantity are made. A new mill is also being built on the upper level, to use a fall of 50 feet, and about 100 horse-power.

13. Finally, the city of Lewiston derives its water-supply from the river, taking the water from above the dam, and pumping, by water-power, "so much water every twenty-four hours as 600 horse-power with a head of 25 feet will pump, to a height of 220 feet, twelve hours in every twenty-four." The water from the wheels is discharged into the river. If the 600 horse-power refers to net power, the quantity of water which can be pumped, according to the above, will be 19 or 20 cubic feet per second during twelve hours; and the quantity of water used for pumping would be about 282 cubic feet per second, making in all some 300 cubic feet per second.

The power at Lewiston is controlled by the Union Water-Power Company, organized September 18, 1878, and succeeding the Franklin Company in the ownership of the canals and water-privileges. The old water-power company was incorporated in 1849, and the first improvements were begun in 1850. The dam is a substantial stone structure, extending in a zigzag direction from rock to rock. The upper level of the canal is about 4,200 feet long, the lower level, 1,600. The company leases power by the horse-power, rates varying, according to circumstances, from \$2 50 to \$12 50 per horse-power per annum, being cheaper for the original corporations. These prices are for the net power on the shafts, being reckoned in all cases as 75 per cent. of the gross power due to the quantity of water and the fall. Measurements are not made regularly, but have lately been made, once for all, to determine the quantity of water used by each mill. Before these were made, the power used was only guessed at. The company obtained control of the lakes at the head of the river in 1877, and has since improved them, their only use previously having been for log-driving purposes. Before their purchase by the company the mills were sometimes short of water in dry seasons, but now full capacity is secured the year round, though in dry weather there is no waste during the day-time. No steam is used in the mills which have been named. They run eleven hours a day.

It will be seen from the above that the total quantity of water taken from the upper level is in the neighborhood of 2,350 cubic feet per second, or would be if the city were to pump all it is entitled to. The daily consumption of water in Lewiston for the year 1881 was 1,016,260 gallons, or about 135,500 cubic feet, or, supposing this pumped in twelve hours, about 3½ cubic feet per second, thus requiring a total quantity of water equal to about 50 cubic feet per second. The total quantity of water taken from the upper level is thus, at present, about 2,100 cubic feet per second during about eleven hours; and this may be taken as the minimum flow of the stream, affording a gross power of about 238 horse-power per foot fall, or, on a total fall of 50 feet, 11,900 horse-power during eleven hours. This power is, of course, not realized, as the total fall is not completely utilized, but over 11,000 gross horse-power are now in use. Were the pond of greater capacity, the power available during working hours would be still more increased. No trouble is experienced with freshets, the range of water on the dam being but 8 feet. The drainage area above Lewiston is 3,120 square miles, and the rainfall is about the same as given on page 79. The city is within 6½ hours of Boston and 1½ hour of Portland, and the power is, no doubt, one of the finest in New England.

Two miles up the river, at Deer rips, there is an unimproved power, stated by Wells as equal to 2,500 horse-power.

Ten miles above Lewiston are Turner Centre falls, with 12 feet fall and good location, but unimproved. The minimum power during twenty-four hours is probably not less than 100 horse-power per foot.

Sixteen miles above Lewiston are North Turner falls, where the fall is 13 feet, and the bed and banks are favorable. The minimum power during twenty-four hours is probably about 97 horse-power per foot, or 1,261 horse-power on a fall of 13 feet. Wells estimates it as 950 horse-power.

The next power is at Livermore Falls, where the natural fall is 22 feet in 30 rods. A dam at the head of the falls raises the water some 7 feet, making the total fall 29 feet; and Wells states that it may be raised 7 feet higher, making the total fall 36 feet. At present only a fall of 14 feet is used, for mills of various kinds, using only a small fraction of the power. The minimum power available during twenty-four hours is probably not less than 80 horse-power per foot fall. The power is said to be a very fine one, and to merit further development.

Half a mile above Livermore Falls are Otis falls, with a fall of 14 feet in 100 feet, altogether unimproved; and a mile and a half above are French's falls, with 10 feet, unimproved. The quantity of water at both is nearly the same as at Livermore Falls.

Three miles above Livermore Falls are Jay Bridge falls. Wells does not state the exact fall, but estimates on 30 feet. The bed and banks are of solid rock, and the location is said to be unsurpassed. The minimum power is about the same as at Livermore Falls. At present a fall of 12 feet is used, but this can no doubt be greatly increased.

At Capen's rips, in Canton, a fall of from 6 to 10 feet occurs in 160 feet, now unutilized, though the site is said to be a good one.

In Rumford we encounter the largest fall on the river, the descent being 162 feet in about a mile. The river is but 90 feet wide, the bed and banks are rock, but the latter suitable for building. A small fraction of the power is used. The drainage area above the falls is about 2,223 square miles, and in the following table I have estimated roughly the power available:

Estimate of power at Rumford Falls.

State of flow (see pages 8–10).	Drainage area.	Flow per second.	Horse-power available (gross), continuously.	
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*162 feet fall.*
Minimum	2,223	550	62.5	10,135
Minimum low season		620	70.0	11,340
Maximum, with storage		1,500	170.5	27,621
Low season, dry years		720	81.8	13,252

Wells estimates the power at 21,546 gross horse-power during working hours. This fall is about 75 miles from tide, and its head is about 600 feet above the sea. Wells estimates the low-season gross power from this point to tide at 85,200 horse-power during eleven hours, which is probably not too large, and a large proportion of which is no doubt available, owing to the favorable condition of the bed and banks. The falls are, unfortunately, 15 miles from the Grand Trunk railway, and therefore rather inaccessible.

The Androscoggin has some falls in New Hampshire, the principal one being Berlin falls, where the river falls nearly 200 feet in a mile. Little power, if any, is used at this place, though the available power is very large. From the state line up to these falls, in fact, there are continuous rapids, affording numerous sites; the stream, however, is much more variable here than lower down, and very little of its power is used.

It is evident from the foregoing that a large number of excellent powers are afforded by the Androscoggin river. If we compare it with the Merrimack we find its elevation, at the junction of its two headwaters, is over four times that of the Merrimack at Franklin, while its drainage area at that point is about the same. Its drainage area at its mouth is but little smaller than that of the Merrimack. Its theoretical power must therefore be considerably greater, and with prudent development there seems no reason why this river should not become one of the principal manufacturing streams of New England. Its reservoirs are not so extensive, nor so completely controlled as are those on the Merrimack, but its available storage is much larger than that used, so that the flow could no doubt be made more uniform were it considered expedient to go to the expense of doing so.

The first tributary of the Androscoggin which is met with as the river is ascended is Sabattus river, which empties from the left bank in Lisbon. It is the outlet of Sabattus pond, and has a large fall, but is not much utilized. The pond covers 4 square miles, and is dammed, so that the flow of the stream is quite constant. Wells mentions falls on this stream aggregating 130 feet, and states that at the lower site a power of 175 horse-power is used, with a fall of 10 feet. The stream seems an excellent one, though comparatively small.

The Little Androscoggin, which enters the Androscoggin from the west, just below Lewiston falls, is an important tributary. It takes its rise in Oxford county, and flows in a southeasterly direction for nearly 30 miles in a straight line, draining a total area of about 381 square miles. Its fall is large, and connected with it are a number of lakes and ponds, of which 21, with a total surface of 21.9 square miles, have been named on page 78. Many of these

being dammed, and used for regulating, its flow is therefore quite constant, and it is considered an excellent water-power stream. It is accessible at all points, being followed by the Grand Trunk railway for its entire length. The first power is at its mouth, the fall within three-quarters of a mile from the Androscoggin river being stated at 70 feet. A dam 10 feet high at the head of the falls affords a fall of 12 or 15 feet at a saw-mill, only a small amount of power being used. Half a mile below, a wooden dam, 30 feet high, affords a fall of 35 feet at a cotton-mill, using 400 horse-power, which can always be obtained. The power and mill are owned by the Little Androscoggin Water-Power Company. Of the total fall, from 10 to 20 feet are lost at times of extreme freshet in the Androscoggin, at which times an engine is run. Judging from the drainage area and the power above, the minimum available power during twenty-four hours would be about 500 net horse-power on a fall of 35 feet.

Wells estimates a minimum flow of 366 cubic feet per second during working hours, or 165 during twenty-four hours, the latter corresponding to a gross power of 18.75 horse-power per foot, 656 horse-power on a fall of 35 feet, and 1,312 horse-power on a fall of 70 feet, and the former corresponding to 1,431 horse-power on 35 feet, and 2,862 horse-power on 70 feet. If this is really the minimum power, the stream is a remarkably constant one.

Two miles above is Rynson's privilege, with an available fall of 20 feet. Wells gives the power as 840 horse-power during eleven hours.

At Mechanics' Falls, about 12 miles, by the river, from its mouth, occurs the next power, there being three dams, and the total fall being about 37 feet in a distance of 950 feet. At the head of the falls a stone dam, 12 feet high, affords a fall of 14 feet, and below are two wooden dams, affording falls of 12 and 8 feet. The power is all used at the paper-mills of the Denison Manufacturing Company. At the upper fall 275 horse-power are obtained during nine months, falling at times to 175 horse-power or below, and a steam-engine being run during about three months. There being no waste in summer, the minimum power is below 175 net horse-power continuously, or the flow is below 150 cubic feet per second. Wells states the flow as 20,000 cubic feet per minute during ordinary working hours (meaning about eleven hours), or 154 cubic feet per second continuously. I think it probable, however, that this is too great for the minimum flow.

Next above is Page's mill, with a fall of 14 feet, then Hackett's mills, 13 feet, and at Minot Corner, 13 feet. There are numerous powers above this, but the stream is small; it is evident, however, that it is a most excellent one in all respects.

Two and a half miles above Lewiston Wilson pond empties into the river. It covers 2,200 acres, and is owned by the Union Water-Power Company, of Lewiston, which has a dam at the outlet 13 feet high, and uses the pond as a reservoir, drawing over 5 feet from it in dry weather.

Twenty-Mile river, which enters from the west, in Turner, affords considerable power, but is a small stream, and cannot be described in detail. It drains about 189 square miles.

Webb's river, which enters from the north, in Dixfield, drains about 169 square miles. At its mouth is a fall of 29 feet in a distance of 200 feet, partially utilized, and 5 miles above it is a fall of 6 feet, unoccupied. The stream is the outlet of Webb's pond, and is said to be a good one for power. The lake covers 3 square miles, and can be made to afford a storage of 9 feet, thus much improving the power below. The stream has many rapids and falls, mostly unimproved.

Swift river, emptying from the north, in Mexico, is an unimportant stream. Not far from the mouth is a fall of 50 feet in half a mile, and above it are Walker's narrows, with 16 feet in 15 rods, and Weeks' falls, with 18 feet in 15 rods. The stream has few ponds connected with it, however, unlike most of the streams in the vicinity, and is therefore exceedingly variable in its flow, so that the powers are not of great value. As its name implies, the stream has a rapid descent, and affords numerous falls and rapids, but little of its power is utilized.

Ellis river, which also enters from the north, about 10 miles above the mouth of Swift river, is a more constant stream, being fed by several ponds. It also has a very rapid fall, Wells enumerating five falls on the main stream and its two branches aggregating 85 feet. The stream drains about 175 square miles, and affords many sites besides those named by Wells. Little of its power is improved.

Wild river, which rises in New Hampshire and flows northeast, entering the Androscoggin in Gilead (Maine), is, as its name implies, an uncontrollable stream. Its freshets are very violent, and, although it has abundant fall, it is little used. It is a true mountain stream. The same may be said of many of the remaining tributaries from New Hampshire, which are variable in flow and little used. Some, however, like Clear stream, which rises in Dixville, near Dixville notch, and flows in a southerly and easterly direction, are bordered by low and sandy plains. In general, then, the power of these tributaries is of no value.

Of the two headwaters of the Androscoggin, the outlet of the lakes affords no power, except at the dams which have been described. The lakes are allowed to flow constantly during the dry season, and at all times a certain minimum quantity must be allowed to pass. A considerable amount of power is available at these dams, but the power in this region will not be much utilized until the means of communication are better than they are now. Above Berlin falls the railroad leaves the river, and the headwaters of the latter flow through an almost unexplored wilderness, covered with virgin forests, and only inhabited by hunters and lumbermen. Little is known regarding their water-power. Between Umbagog and Richardson lakes the fall is 200 feet (see page 78), the stream connecting the two being known as Rapid river, only 5 miles in length. The bed and banks are good, and a very large power

could no doubt be rendered constantly available here. At all the storage dams large powers could be utilized; and some of the tributaries of the lakes also afford sites for power, notably Kennebago river, the outlet of Kennebago pond.

The Magalloway river has its sources in the northwestern corner of Maine, at elevations of from 2,600 to 3,000 feet. Lake Magalloway, near its source, at an elevation of 2,225 feet, covers 320 acres, and at its outlet occurs a cascade some 20 feet in height. The stream is rapid for some distance from the lake, but then becomes very sluggish, and in some parts of its course offers no power for long distances. Its length is 33 miles in a straight line, or 39 following the principal bends. The principal power mentioned on the river is near its mouth, at Ariscoos falls, which extend for nearly two miles along the river. The total fall is said to be in the neighborhood of 100 feet, and a dam 8 feet high at the head of the falls would back the water over 20 miles, thus affording ample storage. The river drains about 416 square miles. No power is utilized upon it.

THE KENNEBEC RIVER.

The Kennebec river, whose basin bounds that of the Androscoggin on the east, has its source in Moosehead lake, the largest sheet of water in the state of Maine, covering an area of 120 square miles, and lying partly in Somerset and partly in Piscataquis county, at an elevation of about 1,023 feet above the sea. From this lake the river pursues its course in a general southerly direction, its mouth, in Merrymeeting bay, lying almost directly south of the outlet of the lake, and about 115 miles distant in a straight line. The stream flows through Somerset, Kennebec, and Sagadahoc counties, and past the towns and cities of Skowhegan, Waterville, Augusta, and Gardiner. Its total length, from the outlet of the lake to the ocean, is 155 miles; from the sources of Moose river, the principal tributary of the lake, 227 miles; from the lake to Augusta, the head of tide and of navigation, 112 miles. The river drains a total area of about 6,400 square miles, and the map shows the form and dimensions of the basin. The principal tributaries are the following:

Name of stream.	Where received.	From which side.	Length. (a)	Drainage area.
			Miles.	*Sq. miles.*
Cobbossecontee river	Gardiner	Right.	36	292
Emerson river	Waterville	Right.	42	a 185
Sandy river	Starks	Right.	60	666
Carrabasset river	Anson	Right.	43	366
Dead river	Bowtown	Right.	64	1,021
Moose river	Moosehead lake	Right.	70	a 650
Sebasticook river	Winslow	Left.	59	1,088
Wesserunsett river	Skowhegan	Left.	25	167

a Wells.

The greater part of the drainage basin lies to the west of the river, and is hilly for 60 miles northward from the sea. Above that, in Somerset county, the hills subside into low undulations, but about the confluence of Dead river, mountains close in upon the river and cover the whole breadth of the basin, while in the vicinity of Moosehead lake the mountains recede or disappear, and the valley opens into a broad plain country. The northwest part of the basin is very rough, being covered with the easterly offsets of the White mountains. The soil is gravel, sand, clay, and loam; the prevailing rocks, gneiss and mica-schist, and good building stones are abundant. Parts of the basin are very thickly wooded, and it was estimated in 1869 that two-thirds of the basin was covered by forests. The elevation of the basin is, on the whole, less than that of the Androscoggin, owing to its greater distance from the White Mountain highlands. Some isolated mountains occur, however, which number among the loftiest peaks in Maine. The following table gives some idea of the slope of the river:

Slope of the Kennebec river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth, Merrymeeting bay	0	0			
Augusta	26±	0	26	0	0
Head of Kendall's Mills rips	48±	91	22	91	4.1
Norridgewock	66±	138	18	47	2.6
Top of dam, Madison bridge	79±	233	13	95	7.3
Head of Caratunk falls	90±	316	11	83	7.5
Moosehead lake	138±	1,023±	48	707	14.7

The average fall of the stream from the lake to Augusta is 9.1 feet per mile, or greater than that of the Androscoggin.

The bed and banks of the river, below the mouth of Dead river, are in every way favorable for power. Between that point and the lake, in which distance the fall is stated as in the neighborhood of 500 feet, the distance being about 28 miles, the river is for the most part "a torrent, walled in by steep precipices of rock from 20 to 50 feet in height", so that only a part of the power could be put to use without excessive outlay.

The rainfall over the basin is about 43 inches, of which 11 fall in spring, 10 in summer, 12 in autumn, and 10 in winter. The flow of the stream is tolerably constant, and could be made much more so by the systematic improvement of the reservoirs connected with it. The average range from lowest to highest water is 7 feet at Augusta, 8 at Waterville, 12 at Skowhegan, above the falls, and 18 below, and from 15 to 20 feet at points above Skowhegan. The variability of the flow is chiefly due to the mountainous character of the upper part of the drainage basin.

The following tables, from Wells, give the principal reservoirs of the Kennebec and its tributaries:

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	Feet.	Feet.
Snow pond	Emerson stream	5.15	4 to 5	*a*4
Long pond	do	4.85	1 to 2	
Great pond	do	9.00	Dam	
Richmond pond	do	0.85		
McGrath pond	do	0.75		
Little pond	do	0.35		
East pond	do	2.50	8	
North and Little ponds	do	4.00		
Nine ponds		27.45		
Big pond	Sandy river	1.00		
Clearwater pond	do	1.75	8	3
Norcross pond	do	0.35		
Chesterville (six small ponds)	do	2.00	Dam	4 or 5
Wilson's pond	do	1.25	7	5
North pond	do	1.00	Dam	(?)
Taylor pond	do	0.20		
Sandy river (four ponds)	do	1.00	2	(*b*)
Lufkin pond	do	1.25		5
Sylvester pond	do	0.30	Dam	
Eighteen ponds		10.10		
Fahi pond	Carrabasset river	0.60	4	4
Sandy pond	do	0.40		
Embden pond	do	3.50	4	12
Hancock pond	do	1.00	4	(*b*)
Spruce pond	do	0.35		
Rowe pond	do	0.70		8
Gilman's pond	do	0.50	Dam	
Judkin's pond	do	0.75		
Butler pond	do	0.40		
Porter's pond	do	1.00	Dam	4
Tuft's pond	do	0.50		(*b*)
Dutton pond	do	0.20	[illegible]	(*b*)
Jerusalem pond	do	0.30	Dam	(*b*)
Middle Carrying-place pond	do	0.30	Dam	(*b*)
Fourteen ponds		10.20		
Spencer pond	Dead river	5.00	8	4
Pond in No. 5, R. 7	do	0.50		6
Great pond	do	4.00		(*c*)
King & Bartlett pond	do	1.00		
Long pond	do	2.00		5
Flag-staff pond	do	3.00	5 to 6	(?)
Carrying-place pond	do	2.00		5
"Jim" pond in No. 1, R. 5, F. Co	do	1.00	8	2

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	Feet.	Feet.
Timbrook pond, in No. 2, R. 4	Dead river	1.25	9	
Chain (three ponds)	do	5.00	8	2
Twelve ponds		24.75		
Brassua lake	Moose river	6.00	No dam.	5
Misery pond, in No. 2, R. 7	do	1.50	2+	(?)
Parlin pond	do	2.75	*d*5	3
Long pond	do	8.00	No dam.	8
Wood pond	do	3.00	No dam.	8
Little and Big Wood ponds	do	1.35	7	
Attean pond	do	5.00	No dam.	8
Holeb pond	do	3.00	No dam.	(?)
Thorndike (two ponds)	do	1.00	*e*6	*f*6
Eleven ponds		31.60		
China pond	Sebasticook river	6.30	6	
Patte's pond	do	0.85		
Lovejoy's pond	do	0.70		
Sandy pond	do	0.95	6	
Twenty-five-mile pond	do	4.25	2	2
Carlton Bog pond	do	1.75		4
Plymouth pond	do	3.00	10	
Skinner's pond	do	0.70		
Stetson pond	do	2.50		(*b*)
Newport pond	do	7.50	4	4
Corinna pond	do	0.60		
Dexter pond	do	3.00	8	
Palmyra (two ponds)	do	0.60		
Stuart's pond	do	0.80		
Indian pond	do	2.50	Dam	
Little Indian pond	do	0.35		
Weymouth pond	do	0.40		
Rogers pond	do	0.90		(*c*)
Mill pond	do	1.10		
Moose pond	do	9.50	4	*g*10
Stafford pond	do	0.35		
Starbird pond	do	0.35		
Barker's pond	do	0.35		
Twenty-four ponds		48.30		
Madison pond	Wesserunsett river	3.00	7	3
Wentworth pond	do	1.00	No dam.	10
Baker's pond	do		No dam.	(?)
Wyman pond	do	0.75	No dam.	9
Weeks' pond	do	0.60	6	
Five ponds		5.35		

a With large flowage. *b* Several feet. *c* Considerable. *d* Formerly. *e* On one pond. *f* On other pond. *g* Or more.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Webber pond	Kennebec river	2.10	6	
Three-mile pond	....do	2.00	8	
Sibley & Morrill pond	....do	2.00		*a* 10
Long pond	....do	0.95		
Austin (five ponds)	....do	3.20		(?)
Robinson's pond	....do	0.75		
Pleasant pond	....do	3.15	4	8
Mores Bog Stream pond	....do			
Otter (two ponds)	....do	0.50		
Chase (three ponds)	....do	1.00		
Mosquito pond	....do	1.00		12
Moxie pond	....do	7.00	6	3
Lower Baker pond	....do	1.00		
Black stream, lower pond	....do	1.25	8	2
Black stream, upper pond	....do	0.59	7	2
Pierce pond	Kennebec river	3.50	10	
Lower Carrying-place pond	....do	1.00		(*b*)
Cold Stream pond	....do	1.25		12
Chase's Stream pond	....do	0.60		
Indian pond	....do	6.00	12	
Moosehead lake	....do	120.00	8	*c* 4
Lower Roach pond	....do	5.00	8	4
Middle Roach pond	....do	2.50		
Upper Roach pond	....do	3.00	Dam	
Tomhegan pond	....do	0.75	No dam.	6
Spencer pond	....do	1.50	4	
Western outlet (three ponds)	....do	1.25		
Thirty-six ponds		173.25		

a On Morrill pond. *b* High dam. *c* By cutting down outlet.

The above are all tributary to the river above the head of tide; the following empty below that point:

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Pleasant pond	Cobbosseecontee river.	1.50	4	6
First Purgatory pond	....do	0.70	3	8
Second Purgatory pond	....do	0.50	Dam	8
Third Purgatory pond	....do	0.20		8
Cochnewagan pond	....do	1.00	7	
Wilson's pond	....do	0.90	4	(?) 0
Cobbosseecontee Great pond	....do	8.00	4	6
Narrows pond	....do	0.90		
South pond	....do	1.95	3	3
North pond	....do	3.00		
Carleton pond	....do	0.40		
Greely pond	....do	0.85		
Sanborn's pond	Cobbosseecontee river.	0.30		(?)
Desert pond	....do	0.30		
Jimmy's pond	....do	0.30		
Fifteen ponds		20.90		
Nequasset pond	Kennebec river	0.80		
Worromontogus pond	....do	1.75	Dam	10
Small ponds in Augusta	....do	1.50		
Great swamp in Dresden	....do	0.90		
Eight ponds		4.95		

The foregoing 152 principal ponds have a total area of 357.15 square miles. The total number of ponds in the basin is 311, with a total area of 450 square miles, or 1 square mile to every 14.2 square miles of basin. Moosehead lake, the principal reservoir, at the head of the stream, has a drainage area of about 1,296 square miles. A dam raises the water about 8 feet, and by cutting down the outlet a storage of 10 or 12 feet can be had. The present storage of 8 feet, however, is probably sufficient to render available the maximum power possible permanently, although a greater storage would be advantageous in most years. The lake is at present not controlled at all for manufacturing purposes, but only by lumbermen, for log-driving. Its value, however, as a regulator of flow is very great.

It may not be uninteresting to insert here a table showing the principal features of the great reservoirs we have hitherto met with, and the relation they bear to the streams they feed. In studying this table, it must be remembered that only the *principal* reservoirs of the large streams are named, and that they have numerous smaller ponds which have considerable influence on the flow of the stream at its lower parts. This is the case with the Merrimack, Androscoggin, Kennebec, and Kennebasis. Other things equal, a stream is more favorable the smaller the distance from the reservoir to the lowest power. The greater the ratio of the capacity of the reservoir to its drainage area, the more favorable the stream in its upper part, and if this ratio is over 0.35, it is probable that the maximum with storage is available at the outlet of the reservoir. (*a*) The greater the numbers in the last two columns the better the stream. It will be seen from this table that few streams are superior to the Kennebec as regards reservoir capacity. It is fully equal to the Merrimack, as shown by the numbers in columns 10 and 12, and only surpassed by some smaller streams whose reservoirs are larger in proportion:

a It is not certain, because the storage capacity is not exactly known.

Table comparing reservoir capacity of some New England streams.

[NOTE.—The figures in the last four columns are in most cases only approximations.]

Name of stream.	Principal reservoirs.	Area of reservoirs.	Elevation above tide.	Drainage area of reservoirs.	Drainage area of stream above lowest power.	Distance from reservoir to lowest power.	Depth controlled on reservoir.	Ratio of area of reservoir to drainage area of reservoir.	Ratio of capacity of reservoir to drainage area of reservoir.	Ratio of area of reservoirs to drainage area of stream.	Ratio of capacity of reservoir to drainage area of stream.
		Sq. m.	*Feet.*	*Sq. m.*	*Sq. m.*	*Miles.*	*Feet.*		*Feet.*		*Feet.*
	Lake Winnipiseogee, etc	83.93	500	400			2.5—	0.210	0.534		
Merrimack river	New Found lake	7.80	597	90	4,599	a 122.00±	3.0	0.087	0.260	0.0225	0.060
	Squam lake	11.75	510	47			3.5	0.250	0.875		
	Lake Winnipiseogee	71.75	500	357		13.65	2.5	0.201	0.502		
Winnipiseogee river	Smith's pond	4.85	540	......	480	....	4.0	....	......	0.1750	0.445
	Great bay, etc	7.33	478	400		7.31	2.0	0.028	0.037		
New Found river	New Found lake	7.80	597	90	95	3.00	3.0	0.087	0.260	0.0820	0.246
Squam river	Squam lake	11.75	510	47	67	2.50	3.5	0.250	0.875	0.1750	0.614
	Great East pond	2.84	499	16		28.00	10.0	0.178	1.770		
Salmon Falls river	Horn pond	0.35	478	22	242	27.00	3.0	0.016	0.048	0.0230	0.200
	Milton Three ponds	2.33	400	123		19.00	8.0	0.019	0.151		
	Other ponds	....	....	......		....	....	....	......		
Presumpscot river	Sebago lake	50.00	251	498	725	22.00	6.0	0.100	0.400±	0.0690	0.276±
	Umbagog lake	18.00	1,256				14.0				
	Richardson lake	21.15	1,456				14–20.0				
Androscoggin river	Mooselucmaguntic lake	21.00	1,486	760	3,698	157.00	14.0	0.101	1.010±	0.0210	0.210±
	Cupsuptic lake	3.00	....				14.0				
	Rangeley lake	14.00	1,511				10.0				
Kennebec river	Moosehead lake	120.00	1,023	1,296	5,907	112.00	8.0—	0.093	0.558±	0.0200	0.120
Kennebasis river	Big lake	14.00	189	580	766	10.00	Small...	0.053	0.200±	0.0400	0.150±
	Grand lake	17.00	271			23.00	8.0				
Chiputneticook river	Chiputneticook Lower lake	27.00	383	400±	634	35.00	15.0	0.130	0.900±	0.0820	0.570±
	Chiputneticook Grand lake	25.00	444			74.00	6.0				

a Distance from Lawrence to Franklin: 110.1 miles; length of Winnipiseogee river: 12 miles; in all, 122 miles ±.

The flow of the Kennebec, though now quite variable, might be rendered much more uniform by the systematic improvement of its reservoirs.

As regards accessibility, the stream is navigable to Augusta for small vessels, and even to Waterville, boats being locked over the Augusta dam. The stream is easily accessible by rail as far up as Caratunk falls, but above that point it is difficult of access, the nearest railroad points being North Anson and Blanchard, the former over 40 miles from the lake, the latter over 20 miles from lake and river.

As the stream is ascended, the first power is met at Augusta. A crib-dam with sloping face, 17 feet high and 956 feet long, ponds the water for 17 miles to Waterville, the average width of the pond being, perhaps, 500 or 600 feet. The old dam, built a good many years ago, was carried away by an ice-freshet in the spring of 1870, and was at once rebuilt. From the dam a canal about 1,000 feet long extends along the west bank of the stream, where the mills are situated. The fall varies a little with the tide, which is said to rise 2 feet, but the level of the water can be raised a foot by flash-boards, and the average fall is about 17 feet.

The power is owned by the Edwards Manufacturing Company, recently organized, but it formerly belonged to the A. & W. Sprague Manufacturing Company, of Rhode Island. Power is used by two cotton-mills belonging to the company, using together in the neighborhood of 500 horse-power, and a number of small mills of various kinds—grist-mills, box factories, sash, door, and blind factories, etc.—the buildings and wheels all belonging to the company, and power being rented at special rates, according to circumstances. The total power used on the west bank is perhaps about 700 horse-power, while on the east bank a saw-mill uses about 200 horse-power. The cotton-mills were not running in 1882, but it was expected to start them at the end of that year. No steam is in use in any of these mills, and, except in heavy freshets, there is always a very large excess of water-power. In freshets the fall is sometimes reduced considerably. In 1878 the water is said to have risen 13 feet on the dam and 20 feet below the dam, but such rises are very rare. In the ice-freshet of 1870, when the old dam was carried away, the water was dammed up below the city, rising some 25 feet below the dam.

The drainage area above Augusta measures about 5,900 square miles. Wells states that in the summer of 1866 the flow was found to be, at a time when the stream was lowest, 2,167 cubic feet per second continuously, but adds that the summer rainfall was large in that year, and estimates the minimum flow at 1,300 cubic feet per second. Estimates are liable to considerable error in the absence of gaugings, but I should judge the power at Augusta to be, at its minimum, not less than that given by Wells, and probably greater.

If we assume the flow as 1,500 cubic feet per second continuously, the gross power would be 170 horse-power per foot, or about 2,900 horse-power on a fall of 17 feet. In the low season of ordinary years the power would probably be 20 or 25 per cent. greater. The pond is large enough, moreover, to allow of the power being considerably increased during working hours.

Augusta is very favorably situated as regards accessibility, both by sea and by land, being only eight hours from Boston. The river is open up to the city during about eight months of the year to vessels drawing 10 feet. The power is an excellent one, and merits more attention than it has hitherto received.

The next power is at Waterville, at the head of the Augusta pond. The falls at this place, known as the "Ticonic falls", amount to 13 feet in a few rods, over a ledge of hard slate. A dam 750 feet long, built in 1869, raises the water 7 feet, and affords a fall of 20 feet, with a race 1,000 feet long. A power of about 2,000 horse-power is used at two cotton-mills and a grist-mill, belonging to the Lockwood Company, full capacity being obtained all the time. The drainage area above the dam is about 4,475 square miles, and I should estimate the minimum power roughly at about 135 horse-power (gross) per foot fall during twenty-four hours, or 2,700 horse-power on a fall of 20 feet. This power would be greatly exceeded in ordinary years. The available power is thus about the same as at Augusta, and both sites are entitled to rank among the best on the river. The pond of the Waterville dam, however, is only 40 rods long, so that the storage is not sufficient to allow of the concentration of the power into working hours.

The next fall above is known as College rapids, where the natural fall is 10 feet in as many rods, capable of being increased to 20 feet by a dam. This site is entirely unimproved, but the figures above enable an idea to be formed of the power available. The two sites together would probably afford a minimum power of at least 5,000 horse-power continuously, and were all the reservoirs tributary to the stream systematically improved and operated, not less than 8,000 horse-power. The topography is said to be singularly favorable for the utilization of the power, and the facilities for transportation are excellent.

At Kendall's Mills, in Fairfield, a dam across the river gives a fall of 22 feet in three-quarters of a mile, the power being owned at the time of Wells' report by the Kendall's Mills Water-Power Company. At Somerset Mills, a short distance up the river, a fall of 12 feet is afforded by a dam, the power being partially utilized. The power at these two places is about the same per foot fall as at Waterville.

The next power is at Skowhegan falls, in the town of Skowhegan. The total fall is 28 feet in half a mile, capable of being increased by a dam, and a considerable fall being in one pitch. The bed and banks are rock, but the topography is only moderately favorable for the location of mills, and the power is only partially improved. The town is accessible by rail. The drainage area above the dam is about 4,176 square miles, and the minimum power may be roughly estimated as about 120 horse-power (gross) per foot fall, or 3,360 horse-power on a fall of 28 feet during twenty-four hours.

The next power is in Norridgewock, 3 miles above the bridge, at Bombazee rips, the natural fall being 8 feet, capable of being increased to 12 feet by a dam. The available power is large, the quantity of water being nearly as great as at Skowhegan.

We next come to the Madison Bridge falls, in Anson and Madison, the largest fall on the river, the descent amounting to 87 feet in 2½ miles. The fall consists of two principal pitches, with swift water between. At the upper pitch a small amount of power is used, and the facilities are said to be remarkably good, the bed and banks being rock. The minimum power available may be estimated at about 100 horse-power (gross) per foot, or 8,700 on the entire fall during twenty-four hours, only a small fraction of which is utilized. In the dry season of an ordinary year the power would probably be at least 60 per cent. greater, or 160 horse-power (gross) per foot, and during working hours, if the water could be stored, this power would be doubled. This magnificent site, which is easily accessible by rail, is worthy of further investigation.

The next power is Caratunk falls, in Embden and Solon, where the descent is 20 feet in one pitch, capable of being increased to 30 feet by a dam. The topography is very favorable, and the minimum power is perhaps about 85 horse-power (gross) per foot fall continuously. The next power is Stand-up rips, a mile above the forks, with 20 feet fall in 100 feet; then comes Moxie rips, 3 miles above the forks, or mouth of Dead river, the fall being 15 feet in 20 rods. Four miles above, at the Black Brook rips, there is a fall of 20 feet in 30 rods. Two miles above this the rapids commence, "extending 9 miles, and in the whole distance the river is a violent torrent, foaming and boiling; the fall being judged not less than 300 feet in this distance. The shores are bold, in part precipitous, and rising to a height of 100 feet on either side". No part of this large power is improved, and probably a large portion of it could not be utilized except at great cost. This power is the last on the river, being only a few miles below the lake.

It is evident from the above enumeration that the powers on the Kennebec are numerous and excellent.

Tributaries of the Kennebec river.—The first important tributary of the Kennebec is the *Cobbosseecontee river*, which enters from the west, in Gardiner, draining about 292 square miles. It is the outlet of a chain of lakes covering over 21 square miles, and rendering the stream an excellent one for power, for its fall is large and the ponds are sufficient to render the flow quite constant. Within a mile of the mouth of the river the stream falls 133 feet to low tide in the Kennebec, and the site, known as the Cobbosseecontee falls, is utilized by a number of mills. The total minimum power has been estimated, according to Wells, at 1,200 horse-power, and at the time of his report there were eight dams at this place. Above this point there are other powers on the river, of which two are in West Gardiner, each with a fall of 16 feet. The stream is an excellent one for power.

In Hallowell the *Vaughan stream* enters from the west, and near its mouth falls 188 feet in about 1,600 feet, a part of the power being used. The stream is small, and its flow is very variable, being unconnected with reservoirs.

Messalouskee or *Emerson's stream*, which joins the Kennebec in Waterville, is an excellent stream, being the outlet of reservoirs covering over 27 square miles, quite sufficient to render the flow very constant, and probably the maximum with storage is available. The length of the stream, from the lowest pond to its mouth, is only about 5 miles, but the total fall in that distance is not less than 164 feet, the greater part of which is utilized in Waterville and West Waterville by mills of various kinds. The greatest fall occurs at the "Cascade", and amounts to 44 feet in 8 rods. The power is excellent. There are other privileges on the upper parts of the stream, between the ponds feeding it, but none of importance.

The next tributary of importance is the *Sebasticook river* which has its sources in Penobscot and Piscataquis counties, and flows in a southwesterly direction, joining the Kennebec at Waterville, and draining about 1,088 square miles. Though a number of ponds are tributary to it, covering in all some 50 square miles, the area of lake surface does not bear such a large proportion to the area of the basin as in the case of some of the smaller streams we have considered, so that its flow is probably more variable. Its fall is considerable, being over 170 feet between Moose pond and its mouth, a distance of some 45 miles, and it affords a number of good powers. In a distance of 5 miles from its mouth the fall is 22½ feet, and a fine power is said to be possible. A mile above this are Lower falls, with 12 feet in half a mile; then Upper falls, 10 feet in a mile; and then Nine-Mile rips, 8 to 12 feet in a mile, part of this power being improved. Then comes Hunter's mills, 7 feet fall, capable of being increased to 10 feet or over; then Ferguson's rips, with 10 feet in 15 rods, in Burnham and Clinton Gore townships; then Eel Weir rips, 8 feet in 80 rods, in Burnham and Pittsfield; and a little above, Thirty-Mile rips, with 35 feet in a mile and a half. This last power is the most important on the river, and is said to be favorably situated, with good facilities for utilization.

The tributaries of the Sebasticook also afford considerable power. In Vassalboro' some power is obtained from the outlet of China pond, which covers an area of 4,000 acres and is 201 feet above tide. Its surface is raised 6 feet by a dam, and the fall of its outlet stream is 160 feet in its course of 6⅓ miles. The maximum with storage is probably available in this case, but the drainage area is small. Wells gives the low season flow as 145 cubic feet per second during eleven hours, and this, on a fall of 160 feet, would afford a gross power of 2,637 horse-power. A considerable proportion of the total fall is utilized. The West branch of the Sebasticook, which joins the other, or East branch, a little above Thirty-Mile rips, in Detroit township, is the outlet of Moose pond, which covers about 9½ square miles and lies at an elevation of 244 feet above tide. Wells mentions the following falls on this branch: Douglass ledge, 14 feet in 150 rods; Hathorn's mill, 14 feet in 40 rods; Call rips, 17 feet in 200 rods, these three being in Pittsfield; Upper Sebasticook falls, 1 mile from the lake, 30 feet in 75 rods, in Hartland; besides others above Moose pond. In Detroit, at the "Rips", there is a fall of 30 or 40 feet in a quarter of a mile, probably on the East or main branch of the river; and farther up this stream, and especially on its tributaries, there are numerous powers in the towns of Newport, Plymouth, Stetson, Corinna, and others. The valley of the Sebasticook is followed by the Maine Central railroad, so that all the water-powers on the stream are easily accessible.

The *Wesserunsett river*, which enters the Kennebec in Skowhegan, from the north, drains about 167 square miles, and is a rapid stream, affording numerous sites, many of which are unimproved. The flow, however, is not very constant.

The next important tributary is *Sandy river*. This stream takes its rise in the western part of Franklin county, near Rangeley lake, at an elevation of 1,868 feet above the sea, and flows first in a southeasterly direction for about 32 miles, when it bends abruptly and flows northeast for about 17 miles in a straight line, entering the Kennebec above Bombazee rips; it drains about 666 square miles. Although fed by a few ponds, the storage capacity of the stream is small, so it is probable that its flow is quite variable. Its fall is large, not less than 1,700 feet from source to mouth, but the greater portion of this occurs where the stream is very small and of little value for power. Nevertheless it offers a number of sites. At Dickerson's rips, in Mercer and Starks, about 8 miles from the mouth, there is a small fall of 8 feet. The minimum power would be probably in the neighborhood of 10 horse-power (gross) per foot fall continuously. In New Sharon, at New Sharon falls, the fall is 10 feet, and is partially improved, while at several other rapids below considerable power is available, though but little is used. At Farmington falls, in Chesterville and Farmington, the fall is 16 feet, only partially used. In Strong there are several powers, and as the upper parts of the stream are approached the fall becomes very rapid, but the river seems to possess no remarkably good sites, those on the lower parts having small falls, while in the upper parts, where a power could be created almost anywhere, the flow is very variable. One remarkable fall in the town of Phillips, only a few miles from the source of the stream, may be mentioned, where, in a distance of 3½ miles, the fall amounts, it is said, to not less than 300 feet.

The *Carrabasset* or *Seven-Mile river*, which enters the Kennebec at Anson, above the Madison Bridge falls, drains about 366 square miles, and has a rapid fall, but its reservoir system is not extensive, and its flow, like that of Sandy river, is quite variable. Near its mouth is a fall of 50 feet in 100 rods, the head of the fall being above the outlet of the largest pond tributary to the stream. Four and a half miles up the stream are Upper Carrabasset falls, said to be a good site, but only partially improved. Numerous sites occur above this, but the freshets are quite severe, and it is said that the mills are sometimes unable to operate more than half the year. Were the reservoirs connected with the stream improved more extensively, the power would probably be much benefited.

Numerous tributaries between this point and the lake empty into the Kennebec from both sides, with very steep descents. Thus, in the town of Pleasant Ridge, the Houston stream is a torrent for nearly 2 miles, the total

fall being estimated at 300 feet. *Fall brook*, in Solon, falls 100 feet in a quarter of a mile, and the *Austin stream*, in Moscow, falls 100 feet in half a mile. These streams are generally very variable in flow, but some of them are connected with ponds, which, if improved, would add greatly to the value of their power.

Dead river, the next and last important affluent of the Kennebec, has its rise in the extreme north of Franklin county, almost on the state line. Its general course is toward the east, and it enters the Kennebec at the forks, or about 22 miles below the lake. The following powers are mentioned by Wells: Dead River rapids, extending from the forks to Grand falls, a distance of 12 miles; Grand falls, in township No. 3, range 4, Somerset county, with 40 feet fall, nearly perpendicular, said to be an excellent site; Long falls, in the same township, a mile long, total fall 30 feet, and a large pond above site for dam; Ledge falls, 12 feet, and Swampscott falls, 10 feet, both unimproved, in township No. 1, range 5, Franklin county, and with a large storage, due to the dam just above, at the outlet of Chain pond, which covers 5 square miles.

The *outlet of Moxie lake*, which enters the Kennebec just above the forks, from the east, has a fall of over 166 feet in a distance of about 5 miles, one fall of 95 feet being perpendicular. The pond affords considerable storage, being commanded by a dam 6 feet high, and the power is doubtless excellent, though comparatively small. Some of the tributaries of Moosehead lake afford power, but little is known regarding them. The principal one is Moose river, which rises at an elevation of over 3,000 feet, and consequently has a fall of about 2,000 feet in its course of a little over 50 miles. It offers numerous powers, mostly unimproved.

The power available on the Kennebec and its tributaries is evidently very large. Wells estimates the power on the main stream alone, between Caratunk falls and tide-water, during a dry season, as 101,000 horse-power during eleven hours; but such estimates are not of great value. It is clear, however, that only a very small fraction of the power available on the main stream is at present utilized.

THE SHEEPSCOT, SAINT GEORGE, ETC.

The area lying along the coast between the basins of the Kennebec and the Penobscot, and comprising about 800 square miles, is drained by a few small streams, which merit a brief notice.

The *Sheepscot river* takes its rise in the extreme west of Waldo county, and flows south into Lincoln, its length being about 37 miles, and its drainage area measuring 248 square miles above tide-water. The *Damariscotta river* is the outlet of the pond of the same name, and, although draining only about 46 square miles above the lowest fall, is of considerable importance on account of its constant flow, the storage on its ponds being probably sufficient to render available the maximum with storage. The *Medomac river* is about 21 miles long, and drains about 118 square miles, above the lowest falls, in Waldo, Knox, and Lincoln counties. Finally, the *Saint George river* is about 35 miles long, and drains, above the lowest falls, about 228 square miles, principally in Waldo and Knox counties.

These streams have generally not a large fall, but their power is quite well utilized, being near the coast; and their reservoirs are so improved as to render their flow quite constant. The whole number of lakes in the district is seventy-two, covering 50 square miles, or 1 square mile to every 50 square miles of drainage area. The following table (from Wells) gives the principal of these lakes and ponds:

Principal reservoirs of the Sheepscot, Saint George, etc.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.	Place.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*			*Sq. miles.*	*Feet.*	*Feet.*
South pond	Saint George river.	1.15			Medomac pond	Medomac river	0.75		
North pond	do	0.50			Little Medomac pond	do	0.25		
Seven-Tree pond	do	1.10		(*a*)	Washington pond	do	1.25		
Crawford's pond	do	1.05	Dam	(*a*)	Clark's pond	do	0.50		10
Round pond	do	0.35		(*a*)	Damariscotta pond	Damariscotta river	10.00	6	
Western pond	do	0.30			Muscongus pond	Muscongus river	0.50	Dam	(*a*)
Senebeck pond	do	1.15		(*a*)	Biscay pond	Pemaquid river	1.00		
Quantabacook pond	do	2.00		(*b*)	Pemaquid pond	do	2.00		6
True's pond	do	0.30	6		Duck pond	do	0.30		
Saint George's pond	do	2.00	Dam		Dyer's Long pond	Dyer's river	1.20	6	4
Stevens' pond	do	0.75	Dam		Dyer's pond	do	0.20		
The "lake"	do	2.00	4	2	Pleasant pond	Sheepscot river	1.10		4 to 6
Lermond pond	do	0.50	8	0	Travel pond	do	0.60		6
Hobbs pond	do	0.25	4	2	Patricktown pond	do	1.00		10
Southern Hobbs pond	do	0.75	0	2	James pond	do	0.30	(*a*)	(*a*)
Fish ponds	do	0.40	6	1	Sheepscot Great pond	do	1.50	Dam	6
Sixteen ponds		14.35			Sixteen ponds		22.45		

a Several feet. *b* Considerable.

On the Sheepscot river the first power is a tide-power at Sheepscot falls. Five miles above, at the head of tide, a fall of 10 feet is used. At the "Rapids", the head of which is 2 miles farther up, there is a fall of 25 feet in a mile, with steep banks on both sides; and above this there are several small powers.

At the outlet of Damariscotta pond the Damariscotta river falls 52 feet in 20 rods, and the power is excellent, though small, being rendered constant by the storage on the pond.

In the town of Bristol the Pemaquid river falls 50 feet in the first 500 feet from tide, and the power, being fed by ponds above, is said to be good, though very small.

On the Medomac river there are eight powers in the town of Waldoboro', with a total fall of about 80 feet, while other falls occur above.

On the Saint George river there is a woolen-mill in the village of Warren, and also a site known as "Knox falls", just above. In the town of Union the stream has considerable fall, and several powers are in use, while in its upper part the fall is still greater.

None of the powers on these streams are of great importance, being all small. They are valuable, however, on account of their constancy.

THE PENOBSCOT RIVER.

This mighty stream, the largest in the state, is divided in its upper parts into several so-called branches, but the West branch, which is properly the main stream, has its sources in the extreme western part of Somerset county, its water-shed on the west being nearly coincident with the state boundary. From the junction of the so-called North and South branches, which unite to form the West branch, the latter stream pursues for about 80 miles, measured in a straight line, a course toward the east and a little southward, passing through Piscataquis and into Penobscot counties and flowing through a chain of lakes. It then bends toward the south and flows for nearly the same distance in a straight line a little west of south, passing the city of Bangor and emptying into Penobscot bay, this part of its course lying almost entirely in Penobscot county. The length of the stream, along its course, from the junction of the North and South branches, is about 170 miles, and its drainage area above its mouth at Sandy point measures about 8,785 square miles, all within the state of Maine. The map of the basin shows that its greatest length is about 160 miles and its greatest breadth about 115 miles. "It is mountainous from the sea to the head of tide, at Bangor, and above; thence northward it is gently undulating up to and throughout the region of the East and Mattawamkeag branches. On the main stream, above Nicatou, it is more broken, and is singularly diversified with lakes, ponds, swamps, streams, hills, valleys, and detached peaks. The Katahdin mountains, the highest in Maine, affording a prospect characteristic and sublime, from the vast breadth of level country overlooked, lie upon the left bank. Farther west the valley becomes merged with that of the Kennebec on the south and the Allaguash on the north, and terminates on the northwest at the highland boundaries of the state, and in the swamps and lagoons which form the common reservoir of the Saint John and the Penobscot. As a whole the valley is uniform in its topographical features." A large proportion of the basin is still covered with forests. The soil is gravel, clay, and loam, and the rocks granite, mica-schist, and clay-slate. The basin is, as a whole, less elevated above the sea than that of the Kennebec or the Androscoggin, although the northern portion is quite elevated, the divide having, according to Wells, a mean height of 1,085 feet, while the headwaters of the West branch are at an elevation of from 1,600 to 2,000 feet. The following table will give some idea of the slope of the river:

Slope of the Penobscot river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0.0	27	0	0.0
Bangor, head of tide	27	0.0			
Foot of Corporation dam, Veazie		5.4			
Crest of Corporation dam, Veazie		20.8			
Foot of Ayer's falls, Orono		27.2			
Head of Ayer's falls, Orono		35.4			
Foot of Great Works falls, Oldtown		57.5	12	92	7.7
Head of Great Works falls, Oldtown		68.6			
Foot of falls at Dwinal's mills, Oldtown		71.8			
Head of falls at Dwinal's mills, Oldtown		78.3			
Foot of falls at Dwinal's mills, Milford		80.7			
Head of falls at Dwinal's mills, Milford	39	92.3			
Mouth of Passadumkeag		106.0	45	98	2.2
Mouth of Mattanawcook		172.0			
Mouth of Mattawamkeag	84	190.0			
Twin lakes (about)		500.0	36	710	19.7
Chesuncook lake	120	900.0			
Northeast of Moosehead lake		1,000.0	80±	609	7.6±
Penobscot lake	200±	1,509.0			

Fig. 21. MAP OF THE DRAINAGE BASIN OF THE PENOBSCOT RIVER.

Principal reservoirs of the Penobscot and tributaries—Continued.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
South pond, in No. 3, R. 4	Mattawamkeag river.	0.75		
Hot Brook pond, in No. 3, R. 4	do	3.50		
Paskahegan lake	do	18		
Pond in No. 3, R. 3	do	1		
Mattawamkeag lake	do	5.50	12	
Caribou pond	do	1.50		
Pond	do	1		
Pleasant lake	do	3.50		(*a*)
Sketicook lake	do	1.25		
Spaulding's lake	do	2.50		
Rockabema lake	do	2.25	5	(*b*)
Mud lake, above Rockabema	do	1.25	8	
Small ponds in Rockabema	do	2.50		
Twenty-one ponds		53.35		
Salmon Stream pond	Mattagamon river.	2		
Katahdin pond	do	0.65		
Pond in No. 4, R. 7	do	1.50		
Bowlin pond	do	1.10		(*b*)
Upper Bowlin (two) ponds	do	0.85		(*b*)
Mattagamon lake	do	5	10	
Mattagamonsis lake	do	2.25	10	
Third lake	do	1.75	6	
Fourth Lake	do	0.90	Dam, 12	
Flowage above Fourth lake	do	1	(*b*)	
Snake pond, in No. 7, R. 11	do	1	Dam, 7	
Big Leadbetter pond	do	0.80	Dam, 10	
Lower Shin pond	do	2.25		
Upper Shin pond	do	1.30		12–20
Pond in No. 5, R. 7	do	1		
First lake	do	1.10	5 to 6	
Second lake	do	1.10	5 to 6	
Seboois lake	do	4.75	5 to 6	
Five ponds in No. 6, R. 8	do	3		
Scraggly lake	do	3		
Wassattiquoick pond	do	1.50		
Webster lake	do	3	10	
Hudson and Wadleigh Brook reservoirs.	do	1.50	(*b*)	
Twenty-eight ponds		42.30		
Pushaw lake	Penobscot river	8		6
Boyd lake	do	1.75		
Little Pushaw pond	do	0.90		
Mud pond	do	0.75		
Pickerel pond, in Alton	do	0.50	Dam	*c* 3
Nichols pond	do	3		
Davis pond	do	0.90		
Holbrook's pond	do	0.90		
Mattanawcook pond	do	1.30	Dam	
Crooked pond	do	0.70	Dam	
Folsom pond	do	0.40	Dam	
Upper pond	do	1.20	Dam	
Pond in Nos. 2 and 3, east of Chester.	do	4.50		
Mattamiscontis pond	do	2		
Lower Mattamiscontis pond	do	0.90		
Cambolasse pond	do	0.65	Dam	
Long pond	do	1	Dam	

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Caribou pond	Penobscot river	0.85	Dam	
Centre pond	do	0.30	Dam	
Madunkeunk pond	do	1		
Nollesemic pond	do	2.50		
Quakish lake	do	1.75		(*d*)
Shad lake	do	0.75		
South Twin lake	do	[illegible]	(*b*)	3
North Twin lake	do	3.25	Dam, 16	3
Mattaceunk lake	do	2.50		
Jo-Mary upper lake	do	3		
Jo-Mary middle lake	do	2.50		
Jo-Mary lower lake	do	3		
Pemedunkcook lake	do	16	(*b*)	3
Milinoket lake	do	18		10–12
Katahdin pond, in No. 2, R. 7	do	2		
First pond, in No. 2, R. 10	do	0.75		
Second pond, in No. 2, R. 10	do	1		
Third pond, in No. 2, R. 10	do	2.50		
Nahmakanta lake	do	3	8	
Unsuntabunt lake	do	3.75	4 to 6	
Sourdnahunk lake	do	3.75		4
Five ponds in A, R. 11	do	4.75	(*e*)	
Penobscot pond, in No. 1, R. 11	do	1		
Three ponds west of Namakanta lake.	do	2.50	(*f*) 4 to 6	
Ripogenus lake	do	2		
Ripogenus pond	do	4		
Caribou lake	do	6.50		
Upper Caribou lake	do	1		
Ragged lake	do	4		
Chesuncook lake	do	22	12 to 13	
Duck pond	do	[illegible]	(*b*)	
Cusabexis lake	do	2	5 to 6	
Umbazooksus lake	do	2.25		
Longley pond, in No. 6, R. 13	do	1.50	Dam, 7	
Black pond	do	1		
Shallow lake	do	2.50	6	
Poland lake	do	0.75		
Cauquomgomoc pond	do	10		(*b*)
Portage pond	do	1.25		
Daggett pond	do	1		
Pond above Daggett	do	0.75		
Loon pond	do	3		(*g*)
Two ponds above Loon	do	1.25		
Hurd (two) ponds	do	1.50		
Wadleigh pond	do	0.75		
Pine Stream (two) ponds	do	1		
Lobster pond	do	6		
Russell pond	do	1	5 to 6	
Luther pond	do	0.90		
Nulhedus pond	do	1		
Two ponds, in No. 3, R. 3	do	1.25		
Two ponds in Bald Mountain township.	do	1.50		
Penobscot lake	do	1.50		
Two ponds in No. 3, north of Hammond township.	do	1.50		
Eighty-four ponds		182.40		
One hundred and eighty-five ponds.		595.20		

a Many feet. *b* Several feet. *c* Over 1.75 square mile. *d* 12-foot dam feasible. *e* Dammed in part. *f* On two ponds. *g* Dam feasible.

In addition to the above, 9 ponds, covering 39 square miles, which naturally belong to the Allaguash system, have been added to the Penobscot system by means of dams, canals, etc.; and over 30 ponds, covering over 31 square miles, are tributary to thestream below its lowest fall.

The Penobscot river is accessible by rail up to the mouth of the Mattawamkeag, or 57 miles from tide-water. Above that point no railroad approaches within many miles of it, and its headwaters are among the pathless forests of the northern part of the state. The rainfall over the basin is about 44 inches, of which 11 fall in spring, 10 in summer, 13 in autumn, and 10 in winter.

The head of tide and of navigation on the Penobscot is at Bangor, where Treat's falls prevent the further ascent of the river. These falls, one mile above the harbor proper, are flowed at high tide, but a dam extending to a height of 15 feet above mean high tide has been proposed, which, with the storage on the pond, and with flash-boards 2 feet high in dry seasons, it is estimated will afford a gross power of 9,000 horse-power during working hours of the driest day, or over 13,000 horse-power by the aid of reservoirs up the river. The bed of the river is ledge, and the facilities for location are said to be excellent. The minimum flow available for power has been estimated at 1,950 cubic feet per second continuously, affording 3,224 gross horse-power on a fall of 15 feet, the increase to 9,000 horse-power being due to the storage on the pond, the use of flash-boards, and the additional fall at low tide. This does not include a considerable amount of water used for the passage of rafts, estimated as at least 25 per cent. of that available for power, thus making the total minimum flow of the river at least 2,440 cubic feet per second.

Within the next 12 miles above Bangor the fall of the river, according to the table on page 90, is not less than 92 feet, or, deducting the 15 feet or more available at Treat's falls, say 70 feet available for power between that place and Milford. This fall comprises a number of separate sites, mentioned by Wells, but not very clearly distinguished, on account of the fact that the river divides and flows in two channels, with large islands between, and there being falls, of course, on both arms. This fact, too, precludes an estimate of the power at each site, as the quantity of water flowing in each of the two arms is not known. It must, therefore, suffice to say, that in all probability the average quantity of water flowing within the 12 miles referred to, when at its minimum, will be not less than 2,250 cubic feet per second, affording, on a fall of 70 feet, a total gross power of nearly 18,000 horse-power continuously, or very much more if the water could be stored during the night and reservoirs constructed up the river. The total power available on the fall of 92 feet, from Milford to tide, is probably not less than 23,000 gross horse-power continuously, or over 50,000 horse-power during eleven hours. The long tract of dead water above Milford would afford a pond sufficient to store a large amount of water during the night, thus rendering certain a large increase of power above that which could be used continuously. The facilities for the utilization of this immense power are said to be very good, the bed of the stream being generally rock, and the banks favorable for the secure location of mills and canals. A railroad follows the river along the entire distance, and navigation is open to Bangor during about eight months of the year. The amount of power now used on this part of the river is very small.

The next power above Milford is in Edinburg and Passadumkeag, at Passadumkeag rapids, where the fall is 7 feet and the bed of the river solid ledge. The power is unimproved. The next site is in Enfield and Howland, at Piscataquis falls, where the river is 900 feet wide, and the fall about 22 feet. The minimum available power is probably between 2,000 and 3,000 horse-power (gross) continuously. Next comes Island rapids, in Chester and Winn, where the fall is not less than 15 feet in 100 rods, capable of being increased by a dam, the minimum available power being probably several thousand horse-power continuously.

Between Chesuncook lake and the mouth of the Mattawamkeag the descent of the Penobscot is more rapid than in any other part of its course, being not less than 700 feet, or about 19 or 20 feet per mile. This portion of its course, too, seems to be especially favorable for power, combining with a large fall the presence of extensive reservoirs close at hand. The descent is broken by numerous falls and rapids, of which the following may be named: In Indian Purchase township, Grand falls, Island falls, Rhine's pitch, and others, aggregating many feet fall, almost the entire stream in this township being rapid, with several pitches of 15 or 20 feet; in Nicatou township, Salmon Stream falls, 20 feet in 75 rods; Jo-Mary rips, 8 or 10 feet; Rockabema rips, just above the mouth of the East branch, and others; in township A, range 7, Rocky rips; Dolby rips, 8 feet; Ledge falls, 12 or 15 feet, and several miles of quite rapid water; in township No. 2, range 10, above Twin lakes, a number of excellent falls; in township No. 3, range 11, several falls, the principal being Ripogenus falls, where the whole fall is 215 feet in about 3 miles; in township No. 5, range 13, Pine Stream rapids, above Chesuncook lake, 12 or 15 feet in 100 rods; and other smaller powers above.

It is evident from these facts that the Penobscot will compare favorably with any stream in the state as regards amount of power available and facilities for utilization. At the same time, probably a smaller proportion of that power is actually used than in the case of any other large stream yet described.

Tributaries of the Penobscot river.—The first tributary to be mentioned is *Marsh river*, which enters from the west, in Waldo county, after draining about 156 square miles. It offers a number of powers, of which Plummer's mills (25 feet), Boyd's mill (15 feet), and Tapley's mill (15 feet), are near the mouth. There are a number of privileges above, many unimproved, but the stream is not very constant in flow, and many of the mills cannot operate all the year.

The *Sowadabscook river*, from the west, is a somewhat similar stream, though rather more constant in flow, and draining 166 square miles. It has a number of powers, but none of much importance. Were its natural reservoirs improved by storage, its power would be much increased in value, and the mills would be able to operate all the year.

The *Kenduskeag river* from the west, in Bangor, is a larger stream, draining 229 square miles, and much more valuable for power. In Bangor, the stream falls some 75 feet, and a considerable portion of the power is improved, while in the townships above there are many mills, as the table on page 107 shows. This stream, like the two just described, is naturally quite variable in flow.

Great Works river, from the east, affords a number of powers, partly utilized.

Pushaw river from the west, is a stream very like the Kenduskeag, which it adjoins. No important powers on it, however, are mentioned by Wells.

The *Passadumkeag river* from the east, drains about 400 square miles, and is much more favorably situated as regards storage than any of the tributaries thus far, as shown by the table on page 91. Its fall is quite rapid, and in the town of Lowell, Wells mentions four privileges aggregating 48 feet fall. In township No. 3, Hancock county, at Grand falls, the river falls 100 feet in 200 rods, affording, according to Wells, a series of most excellent powers, as regards facilities for utilization. On the outlet stream of Nicatous lake, a tributary of the Passadumkeag, there is a fall of 40 feet in half a mile, and as there is a dam at the outlet of the lake, giving a storage depth of 10 feet, the flow could be rendered quite constant were the storage used for other than log-driving purposes.

The Piscataquis river, which enters the Penobscot from the west, in the town of Howland, is the principal tributary of the latter stream. Its sources lie in the southwestern part of Piscataquis county, and partly in Somerset, and its course is nearly due east for a distance of about 55 miles, its drainage area measuring 1,541 square miles. It is well supplied with reservoirs, which, with systematic improvement, would render the flow quite constant. The stream is about 250 feet wide for 25 miles from its mouth. As regards accessibility, the stream is greatly favored, being followed closely by a railroad from the mouth of the Sebec, about 20 miles from its mouth, to near its headwaters, at Blanchard. The fall of the river in the lower 20 miles of its course, below the mouth of the Sebec, is about 140 feet, or 7 feet per mile; in the next 15 miles it falls about 100 feet, while above that point its descent is probably more rapid still. At the mouth of the river are Howland falls, with a fall of 20 feet, produced by a dam, and once utilized by saw-mills. The minimum available power is probably not less than 600 horse-power (gross) on a fall of 20 feet, continuously, and very much more were the reservoirs improved. Moreover, the dam ponds the water back for 6 miles or more, thus allowing of a large increase of power during working hours, so that the privilege is an excellent one. In Maxfield the river has two sites, McIntosh's and Whitney's falls, each with 8 feet available, but rather less water than below, the Seboois river, the outlet of Seboois lake, entering between. The latter stream has no power of note, but its lake is valuable for storage. In Medford, Piscataquis county, the Piscataquis has Schoodic falls, just below the mouth of the Schoodic river, with 15 feet in 100 rods, and Little falls, 10 feet in 30 rods. The outlet of Schoodic lake has a fall of 22 feet in 35 rods, and its lake is valuable for storage. The next power on the Piscataquis is in Foxcroft and Dover, where, at Dover village, there is a fall of 23½ feet at Dover Great falls, utilized by various mills. There is also a fall of 6 feet 100 rods below, a dam 9 feet high at Dover Lower Village falls, at East Dover, a fall of 12 feet at Foxcroft dam, used by a number of mills, and a nearly equal fall at Pratt's rips, making in all, in the two townships referred to, a total fall of over 60 feet available. The drainage area above these falls is about 387 square miles, but the minimum power available is probably small, on account of the absence of lakes above, perhaps not over 6 horse-power per foot fall continuously. In Guilford several sites are in use, and in Blanchard the river falls 200 to 300 feet in a mile at Grand falls, but only a part of this is available, and the stream is small and inconstant. Other and smaller falls above need no mention.

The Sebec river, the outlet of Sebec lake, is a quite constant stream, and has a fall of 9 feet at Sebec falls, in Milo; a second, of 25 feet in half a mile, 2 miles below the lake; and a third, of 18 feet, at the foot of the lake. The lake covers about 14 square miles, and is very valuable as a storage reservoir. Pleasant river, also a tributary of the Piscataquis, is a larger but probably more variable stream, though its reservoirs would be sufficient, if improved, to regulate its flow to a large extent. Its powers are not of great importance, at least such as are mentioned by Wells.

The next important tributary of the Penobscot is the Mattawamkeag river, which enters from the east at Mattawamkeag. It has its sources in Aroostook county, and flows south and west, draining about 1,533 square miles. It has a number of ponds connected with it, and is probably similar in character to the Piscataquis, though perhaps not so constant in flow. The fall of the stream is rapid, and within a few miles of the mouth, in the towns of Mattawamkeag and Winn, are a number of powers, the exact fall of which cannot be stated. Other sites exist on the upper part of the stream, but few details are at hand regarding them. In Island Falls plantation a fall of 20 feet is used by a few mills, but the power used on the stream is small. Some of its tributaries have rapid descents and good sites. Mattakeunk river falls 100 feet in 2½ miles, but the stream is very small; lower down, in Winn, there is a fall of 50 feet in 100 rods at Upper Mattakeunk falls, and 15 feet in 125 rods at Lower Mattakeunk falls. The Molunkus, Baskahegan, and other tributaries afford abundant power, but no details can be given.

The East branch of the Penobscot, or Mattagamon river, has a rapid fall, its source, lake Mattagamon, lying at an elevation of about 850 feet, or 660 feet above the Penobscot at the mouth of the Mattawamkeag, much the greater part of which descent occurs on the East branch. Few sites, however, are mentioned by Wells, the principal being in township No. 5, range 8, Penobscot county, where, at Bowlin falls, the fall is 8 feet, at Hulling

Fig 22. MAP OF THE STREAMS OF EASTERN MAINE.

Machine falls 12 feet, and at Grand falls 20 feet. There are similar falls in township No. 6, range 8. The power of the stream is little used, but its storage facilities are good, and the flow could be regulated to a considerable extent.

The various small upper tributaries of the Penobscot have considerable power, but are little used. Were they easily accessible, and their reservoirs improved, their power would be valuable.

THE UNION RIVER AND OTHERS.

Between the Penobscot and the Saint Croix rivers are a number of smaller streams, which merit a short notice.

THE UNION RIVER.

This stream is comprised almost entirely within the limits of Hancock county, rising near its northern boundary and pursuing its course southward through a distance of about 45 miles, draining a total area of about 584 square miles above the head of tide-water, at Ellsworth Falls. Its valley is narrow and its tributaries short. The headwaters of the stream lie at elevations of from 225 to 250 feet above the sea, and the interior of the basin is a strongly-defined valley, of a rolling surface, encompassed on nearly all sides by rugged highlands. A large proportion of the basin is covered with forests, and the lakes are sufficient in number to render the flow quite constant, though not yet systematically improved. The extreme range of water at Ellsworth is 7 feet. The following table (from Wells) gives the principal reservoirs connected with the stream:

Name.	Approximate area.	Present storage (1869).	Additional storage feasible.
	Sq. miles.	*Feet.*	*Feet.*
Branch pond	3.75	10	10
Rocky pond, in Orland	0.35	10	10
Reed's pond	4.25	[illegible]	14
Beech Hill pond	1.85	6	14
Mountain pond	1.25	6	14
Hat Case pond	0.50	....	....
Molasses pond	2.25	10	2
Scammon pond	1	....	....
Abram's pond	0.80	10	....
Webb's pond	1.75	10	....
Spectacle pond	2.10	8	3
Rocky pond	0.40	10	5
Rocky pond, in No. 22	1.15	....	....
Two Lead Mountain ponds	2	6 and 8	3 and 4
Brandy pond	1.60	6	....
Great pond	1.50	13	10
Long pond	1	8	5
Alligator pond	1.80	6	5
Morrison's pond	0.35	8	....
Middle Branch pond, upper	1.25	6	5
Middle Branch pond, lower		5	5
Flood's pond	1	9	5
Springy pond	0.60	9	5
Hopkins' pond	1.75	No dam ...	5
George's pond	0.90	....	....
Twenty-six ponds	34.85	....	....

The total number of ponds above Ellsworth is 43, with a total area of 60 square miles, or 1 square mile to every 9.7 square miles of basin. The mean annual rainfall is about 48 inches, 12 in spring, 10 in summer, 14 in autumn, and 12 in winter, a distribution very favorable to constant flow. The slope of the stream may be seen from the fact that the lake in the northern part of the basin lies at an elevation of 205 feet, making the average fall of the river to tide-water about 4 feet per mile, or considerably smaller than that of the larger streams of Maine.

The first power on the stream is at Ellsworth Falls, at the head of tide and of navigation, the river being closed to navigation below this point during about four months of the year. The total fall is stated at 85 feet in about 2 miles, or 100 feet in $2\frac{1}{4}$ miles, and a part of the power is utilized by mills of various kinds, but principally saw-mills, the storage on the ponds above being used principally for log-driving purposes (Wells). The upper dam ponds the water for 12 or 15 miles, thus creating a reservoir large enough to allow of the concentration of power into working hours. No measurements of the power available are at hand, but I should judge the minimum power to be about 12 horse-power per foot fall continuously, or 24 during twelve hours, which would probably be practicable. This would, therefore, amount to 2,400 horse-power (gross) on the entire fall of 100 feet. The site is accessible by rail, and the facilities for development are said to be good. The power estimated could of course be largely increased, probably more than doubled, were the reservoirs systematically improved.

There are no important powers above this, though some sites are named by Wells on the upper branches of the river. Some of the tributaries afford good constant powers, though small.

There are in Hancock county a number of tidal powers, but no others of importance, the Union river being the only considerable stream in the county.

THE NARRAGUAGUS RIVER.

This is a small stream, draining about 260 square miles in Hancock and Washington counties, and flowing in a nearly southerly direction, its length being about 50 miles. It has a number of ponds connected with it, and its flow is not very variable, but none of its powers are very important. At the head of tide-water are the Cherryfield falls, where six privileges exist, with a total fall of 52 feet, affording an excellent power, with a reservoir above sufficient to allow of the concentration of the flow into working hours. At the Great falls, in Deblois, there is a second fall of about 50 feet in half a mile, and the power is said to be a fine one. The minimum power of the river, at its mouth, may be roughly estimated at about 5 horse-power per foot fall continuously.

The Pleasant river, Chandler's river, and Tunk river are small streams near the coast, almost all of which have several sites where the fall is considerable, but the power is small.

THE EAST AND WEST MACHIAS RIVERS.

The West Machias river, confined almost entirely within Washington county, drains an area of about 458 square miles, flowing in a southerly and easterly direction, its length being some 45 miles, measured in a straight line. Its fall is considerable, the elevation of its headwaters being some 400 feet, and its slope being about 5.8 feet per mile, according to Wells. Its flow is not very variable, being regulated to a considerable extent by a number of lakes and ponds, and a considerable portion of its drainage basin being wooded. The total area of lake surface in its basin is 32 square miles, or 1 square mile to 14 square miles of basin. Seventeen lakes have a total area of 30.55 square miles, and a number of them are dammed, though used principally for log-driving purposes. Being situated near the headwaters of the river, their drainage areas are small, and their importance less than would be expected from their size.

The river offers a number of good privileges. At the head of tide and of navigation, 6 miles from the mouth of the stream and 3 miles above where it joins the East Machias, there is a fall of 33 feet (?) to high tide, utilized to some extent. In the absence of gaugings, I should roughly estimate the minimum power as about 10 horse-power (gross) per foot fall continuously. It is stated as greater, but on what authority I do not know. The power is apparently a good one. At Middle falls, in Whitney, there is a fall of 10 feet; and at Great falls, 5 miles above, in Centreville, a fall of 20 feet, with excellent facilities for improvement. In Northfield there is a fall of 28 feet at Holmes' falls, and there are a number of smaller powers above, which need not be mentioned. Any one may estimate the power available by comparison with the data given on pages 8 to 10.

The East Machias river is a stream similar to that just described, but is more constant in its flow. It is entirely confined to Washington county, and pursues a course nearly south, draining about 345 square miles, and with 38 square miles of lake and pond surface, or one-ninth of the area of the basin. The lakes are not all situated near the headwaters of the stream, but are more equally distributed over the basin, thus rendering the flow of the stream quite uniform, though the lakes are said to be used principally for log-driving.

The principal power on the stream is at the head of tide, where the fall is 47 feet in 3 miles, and is used in four privileges. The minimum power is probably not far from that on the West Machias, or, say, 10 horse-power per foot fall continuously, and very much more if the reservoirs were fully improved, as, in fact, they may have been since Wells' report was made. The site is no doubt a good one, though the power cannot be stated more accurately. Other powers exist above, as the fall of the stream is nearly as great as that of the West Machias, but little of the power available is utilized, and no details need be given.

A few other streams exist west of the Saint Croix, viz, the Dennys, Pemaquan, and others, but they are so small as to merit no particular description. Being regulated by a number of lakes, their flow is quite uniform, and their fall being tolerably rapid, they offer some excellent small powers, many of which are to some extent improved. None of them, however, require further notice here.

THE SAINT CROIX RIVER IN MAINE.

The Saint Croix river, the last of the proper coast streams of Maine, is formed by the union of two branches, "the Northern or Eastern, called the Upper Saint Croix or Chiputneticook river, the outlet of the Chiputneticook lakes; and the Western, called the Kennebasis river, which discharges the Kennebasis lakes". The course of the stream is southeast, and its length, from the junction of the two branches to tide, is about 20 miles. The Chiputneticook, and the main stream below it, form the boundary between the state of Maine on the west and the province of New Brunswick on the east. Of that part of the basin lying in Maine, almost the whole is comprised in Washington county, and only this part of the basin is here to be considered. From tide-water at Calais to the head of North lake, the source of the Chiputneticook, the distance is about 97 miles, by the course of the river, while the Kennebasis river is about 42 miles long from its extreme headwaters to the Chiputneticook, and 62 miles to tide. The drainage basin is undulating and hilly, but not mountainous, and a large proportion is still covered with

forests. It comprises a total area of about 1,674 square miles above the head of tide at Calais, of which about 1,100 are in Maine and the rest in New Brunswick, the Chiputneticook draining about 634 square miles, and the Kennebasis about 766 square miles. The basin, as a whole, is less elevated than that of any large stream of Maine which we have yet considered, but the slope of the stream is, nevertheless, quite large, as is shown by the following table:

Declivity of the Saint Croix river.

Place.		Distance from Calais.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
		Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Head of tide at Calais		0	0			
Junction of two branches		20	166	20	166	8.3
Foot of Chiputneticook (Schoodic) lake	East branch.	55	383	35	217	6.2
Head of Chiputneticook (Schoodic) lake	East branch.	75	383	20	....	....
North lake, head of stream	East branch.	96	444	21	61	2.9
Junction of two branches		20	166			
Just below Big lake	West branch.	29	186	9	20	2.2
Head of Big lake	West branch.	40	189	11	3	0.3
Grand lake, foot	West branch.	43	271	3	82	27.3
Grand lake, head	West branch.	55	271	12	....	....

The average slope of the East branch is about 3.7 feet per mile, and of the West branch, below Grand lake, about 4.6 feet per mile. From Chiputneticook lake to tide the fall averages 7 feet per mile, and from Grand lake to tide 6.3 feet per mile.

The flow of the stream is naturally very constant, and, on account of the extensive forests and the large area of lake surface, might be made more uniform, it is said, than that of any other large river in the state, excepting the Presumpscot and the Fish rivers. The total number of lakes in the basin is 61, covering a total area of 150 square miles, or 1 square mile to every 11 square miles of basin. The following table gives the principal of these reservoirs:

Principal reservoirs of the Saint Croix river.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Lewey's lake	Kennebasis branch	0.85	Slight	8
Long lake	....do	1.25	....do	6
Big lake	....do	*a*14	....do	10
Grand lake	....do	17	8	(*a*)
Pocumpus lake	....do	2.50	*b* 6	....
Machias lake	....do	2	3	....
Sysledobsis lake	....do	7	8	....
Sysledobsissis lake	....do	4	3	....
Horseshoe lake	....do	0.75	5	....
Oxbrook lake	....do	1	3	....
Shaw lake	....do	1.75	....	....
Junior lake	....do	6	....	....
Mill-privilege lake	....do	0.75	6	....
Scraggly lake	....do	3	....	....
Pleasant lake	....do	2	4	6
Duck lake	....do	0.75	4	4
Chain (two lakes)	....do	1.50	4	....
Little River lake	....do	0.80	3	....
West Musquash lake	....do	3	4	....
Musquash lake	....do	1.25	7	....
Farrer's lake	....do	0.75	4	....
Tomah (three lakes)	....do	2	Dam	....
Clifford (four lakes)	....do	2	5	....
Twenty-two lakes		75.90	....	....
Chiputneticook lower lake	Chiputneticook branch	27	15	....
Chiputneticook Grand lake	....do	25	6	....
North lake	....do	3.50	3	....
Lambert's lake	....do	2	4	....
Enoch's lake	....do	0.75	Slight	....
Five lakes		58.25	....	....

a Several feet. *b* By Grand Lake dam.

Besides those named, there are others in New Brunswick. Were these reservoirs all improved to their full capacity the flow of the river would be very constant; as it is, the greatest range of water is stated at only about 8 feet, and the freshets are comparatively harmless. Artificial reservoirs are also said to be particularly feasible, there being considerable areas of low ground along the river capable of being flowed, and, in fact, subject to overflow during high freshets. The storage on the lake was, at the time of Wells' report, only used for log-driving purposes. The rainfall over the basin is about 10 inches in spring, summer, and winter, and 14 in autumn, or 44 inches annually, on the average.

The stream is accessible by rail, without much difficulty, up to the junction of the two branches; above that it is more difficult of access, the East branch especially.

The first power met with is at the head of tide, at Calais, the rise and fall of the tide being about 8 feet. The first fall, known as "Salt Water falls", amounts to 10 feet, but the power is not valuable, on account of interruption at high tide, and is little utilized. At Union falls, about half a mile above, a dam extends across the river, and the power is partially utilized. The fall is not stated. At Salmon falls, a mile still farther up, some power is also used; and at Milltown there is also power in use, there being two dams. The total fall in Calais is said to amount to 72 feet, and the facilities for its complete utilization to be excellent. The minimum power cannot be given very accurately, but is probably not less than about 40 or 50 horse-power (gross) per foot fall continuously, or about double that amount during working hours. If we call it 45 horse-power continuously, the total power is over 3,000 horse-power continuously, or nearly 7,000 horse-power during working hours. This could be still further increased, and by a considerable amount, were the lakes better improved.

The next power is at Baring mills, 3 miles above Milltown. A dam crosses the river, giving a fall of 10 feet, and the power is partially utilized. The width of the river is about 500 feet from this place to tide, and for 4 or 5 miles above.

Five miles above the Baring mills we come to Sprague's falls, where the fall is 25 feet, affording one of the best powers on the stream. The minimum power continuously is probably not less than 40 horse-power (gross) per foot fall, or 1,000 horse-power on a fall of 25 feet, or about double this amount during working hours. Were the reservoirs improved to their full capacity the available power here and below would probably be increased to 125 horse-power per foot fall continuously, and during ordinary years it probably does not fall below 60 horse-power per foot fall, or 1,500 horse-power on a fall of 25 feet continuously.

At Enoch's rips, half a mile above Sprague's falls, the fall is 9 feet, and the quantity of water about the same as at the latter privilege.

The last fall below the junction of the two branches of the river is Grand falls, 6 miles above Enoch's rips, and just below the junction. The falls consist of two pitches, about half a mile apart, each pitch having a descent of about 18 feet. The privilege is one of the finest on the river. The drainage area measures about 1,400 square miles, and the minimum power is probably in the neighborhood of 40 horse-power (gross) per foot fall continuously, or 1,440 horse-power on a fall of 36 feet. With complete utilization of the reservoirs, so as to render available the maximum with storage, the power could be probably increased to from 110 to 120 horse power per foot continuously. The extent to which the power on this stream may be improved, by the improvement of its reservoir facilities, renders it remarkable among the rivers of the state.

The West branch, or Kennebasis river, also known as the Schoodic river, drains an area of about 766 square miles, and includes a large extent of lake surface. Its flow is therefore very uniform, and its powers are excellent. Between its mouth and Big lake, a distance of about 10 miles, the fall is about 20 feet, including several rapids and one improved privilege, with a fall of 8 feet. The storage on the lakes is used only for log-driving, but if used for regulating would improve the powers very much. The principal fall on the stream occurs between Big lake and Grand lake, amounting to 82 feet in a distance of about 3 miles. At the head of the fall a dam was built in 1867 by the Saint Croix Log-Driving Company, to hold a depth of about 8 feet on Grand lake. The privilege is said to be a most excellent one, and the power would be unfailing on account of the large storage above. There are other good powers in the neighborhood, mostly unimproved; thus the East and West Musquash streams, outlets of lakes of the same names, fall 100 and 60 feet respectively in their course to Big lake, the outlet of Wawbawsoos or Machias lake falls 40 feet in a short distance, and the outlet of Upper Chain lake falls 30 feet to lake Sysledobsis. All of these powers are comparatively constant.

The Chiputneticook, or East branch of the Saint Croix, has likewise a number of good privileges, of which Wells names the following: Grand Chiputneticook falls, 2 miles above mouth, 21 feet fall in three-quarters of a mile; Canoose rips, 10 miles above mouth, 11 feet fall in half a mile; Haycock rips, 13½ miles from mouth, 6 feet fall in half a mile; Meeting-House rips, 15 miles from mouth, 8 feet fall in a mile; Rocky rips, 3 miles long, the foot being 16 miles above mouth, 25 feet fall; Mile rips, 1 mile long, the foot 30 miles from mouth, 23 feet fall; Kill-me-quick rips, 34 miles from mouth, 10 feet fall in half a mile. These are all below Chiputneticook lake, at the outlet of which the Saint Croix Log-Driving Company has erected a dam holding a storage of 15 feet on the lake. Between the latter and Grand lake, in a distance of about 3 miles, there is a fall of about 60 feet, the upper lake being also controlled by a dam. This power is said to be a good one.

It is evident that the Saint Croix, like all the other streams of Maine yet described, offers a number of good sites, and the table of utilized power shows that the amount of power at present in use is small.

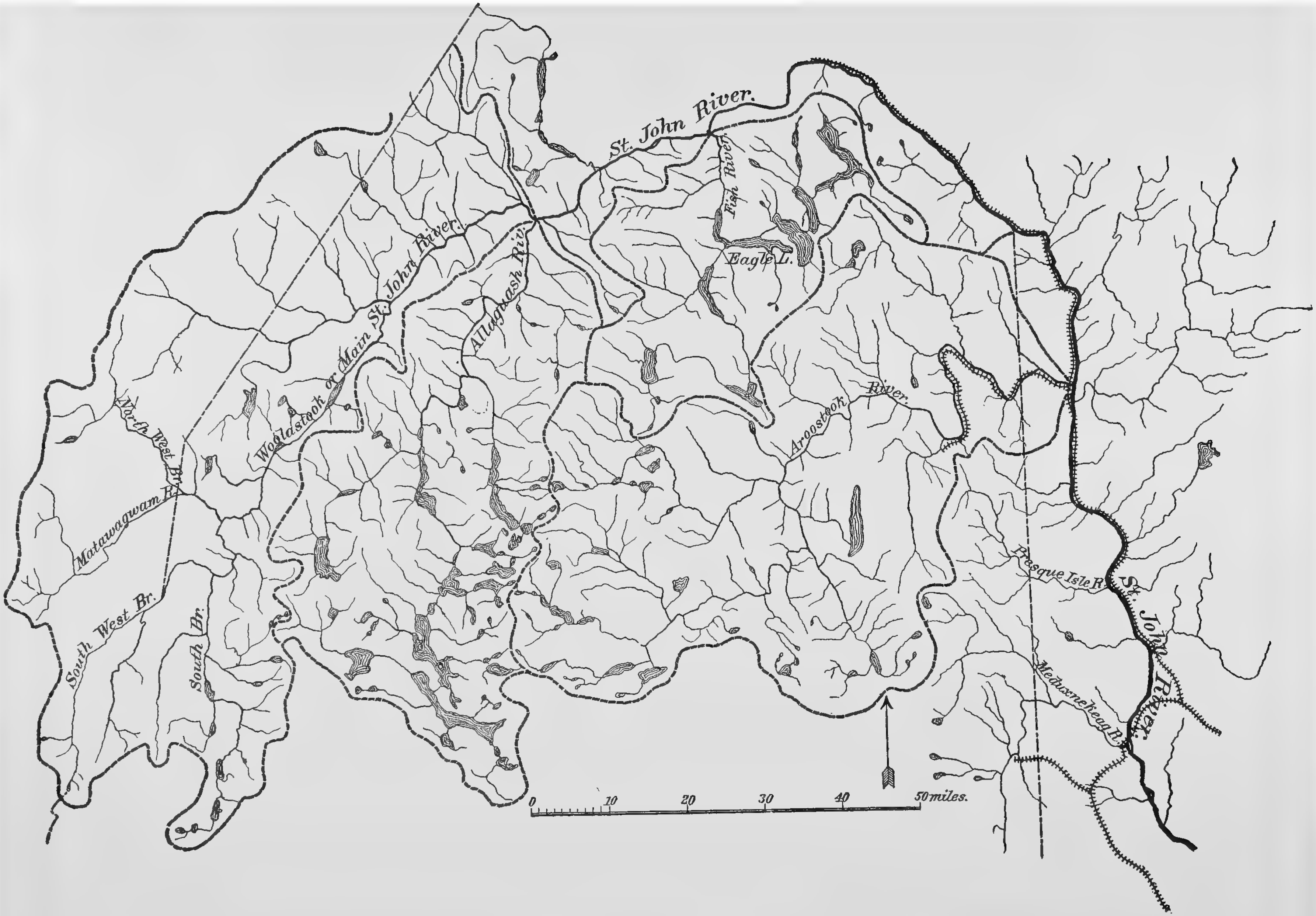

Fig. 23. MAP OF THE DRAINAGE BASIN OF THE ST. JOHN RIVER IN MAINE.

THE SAINT JOHN RIVER IN MAINE.

This stream, the last to be considered in this report, drains the northern slope of the state of Maine, comprising all the area included between its northern, eastern, and western boundaries, and the drainage basins of the streams which have been described in the previous pages. The course of the river is circuitous. The main stream is formed almost on the northern boundary of Somerset county by the union of several branches, the Northwest branch rising in Canada and flowing southeast; the Southwest branch flowing in a northeasterly direction and forming for almost its entire length the western boundary of the state; and the South branch, rising in Somerset county and flowing north. From the junction of these branches the stream, known in the upper part of its course as the Woolastook, flows first northeast to the northern boundary of the state, then east and southeast, passing into New Brunswick and bending toward the south, only to bend once more and flow nearly eastward to the sea. According to Wells, "the total length of the Saint John, in Maine, is estimated as not far from 211 miles, including the more important meanderings", while "its total length, from its remotest sources to the sea, is about 450 miles". According to the same authority, "the area of the whole Saint John basin is 26,000 square miles", while that part in Maine measures 7,400 square miles. My own measurement of the Maine basin gave its area as about 8,000 square miles. As no map of Canada was at hand, I have not been able to measure the total drainage basin of the stream above certain points, but on account of the small amount of power on the river this is not important. Next to the basin of the Androscoggin, that of the Saint John is the most elevated in Maine, but its height, as Wells remarks, is due to a considerable altitude over its whole extent, rather than to an extreme elevation in any part. "It is, therefore, indicative and productive of less fall and power on the streams than are found upon equal areas of the southern slope." "The elevation of the river above tide at the eastern boundary of the state is 419 feet, and at the mouth of the Saint Francis, 606 feet. The distance being about 70 miles, the mean slope is at the rate of 2.7 feet per mile." At the junction of the three branches the elevation of the stream is probably about 750 feet; the mean slope from this point to the eastern state boundary is, therefore, about 2.1 feet per mile, and to the mouth of the Saint Francis, 88 miles according to Wells, about 1.6 feet per mile. The slope is therefore much less than that of any stream of large size in Maine, and the river is of comparatively little value as a source of power. Wells states that it is navigable for its whole length in Maine.

The drainage basin of the stream in Maine is almost entirely covered by unbroken forests, and is topographically very uniform in character. "In the eastern or lower portion, bordering the river, the face of the country is very nearly level, and at a distance from it gradually becomes undulating and moderately hilly, until it subsides into and is merged in the flat country bordering the Aroostook river. Highlands of low elevation diversify its aspect in the mid-district about the mouth of the Saint Francis and Allaguash rivers. Beyond the confluence of these streams the valley of the upper Saint John is quite level nearly to the boundary highlands on the west and southwest. Accordingly, large portions of it are swampy, the pitch of the water-sheds not being sufficient to throw off the surplus water into the drainage channels." "Rock is less exposed than on the southern slope, and building stone less easily procurable."

In regard to the flow of the stream, although no measurements, or even observations, have been made, it would seem to follow, from the immense forests, the uniform topography, and the numerous lakes, that the minimum flow must be large; while, on the other hand, the rise in freshets, on account of the small slope of the stream, may be also quite large. The following table, from Wells, gives the lakes in the basin:

Principal reservoirs of the Saint John river in Maine.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.	Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*			*Sq. miles.*	*Feet.*	*Feet.*
Chapman Plantation lake	Aroostook river	1							
Squawpan lake	do	10		5	Three ponds above Mansungun lake	Aroostook river	1.50		
Saint Croix Lake, in No. 8, R. 4	do	2.50	4		Pond north of Mansungun lake	do	1.10		
Two ponds in No. 8, R. 3	do	1.50			Goddard's pond	do	0.90		
Tracy pond, No. 7, R. 4	do	1.30			Mooseleuk lake, in No. 9, R. 8	do	3		
Umcolcus pond	do	3			Big Machias lake	do	2	Dam, 12.	
Pond in No. 7, R. 6	do	1.25			Pond south of Big Machias lake	do	1		
Sapompeag ponds (two)	do	2.50			Lake in No. 11, R. 8	do	3		
Millnokett lake	do	5		12	Lake in No. 11, R. 9	do	1.10		
Little Millnokett lake	do	3.50			Nashville Plantation pond	do	1		
No. 7 pond, above Millnokett	do	1			Salmon Brook lake	do	1		
Pond in No. 7, R. 10	do	1.10			Madawska lake	do	4		
Pond in Nos. 7 and 8, R. 10	do	1.20							
Mansungun lake	do	5			Thirty ponds		59.95		
Pond below Mansungun lake	do	1							

Principal reservoirs of the Saint John river in Maine—Continued.

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Keeobscus pond, upper	Allaguash river	1		
Keeobscus pond, lower	do	1.15		
Pataquongomis lake	do	2.75		
The Five lakes	do	11		
The Long lakes	do	10		
Lake in No. 10, R. 13	do	3		Many.
Chemquasabamtic lake	do	8		
Heron or Harrow lake, in No. 10	do	2.75		
Churchill lake	do	8		(*a*)
Heron lake, in No. 8	do	4		(*b*)
Pomgocwahem lake	do	11		(*b*)
Indian lake	do	3	Dam, 6	
Spider lake	do	4	Dam, 5	
Pleasant lake	do	4		
Soper flowage and pond	do	2	Dam, 10	
Smith brook flowage	do	3	Dam, 12	
Pomgocquamoc lake	do	3	Dam	(*c*)
Pillsbury pond	do	1.50	Dam, 8	(*c*)
Mad pond, in No. 9, R. 12	do	1.50	Dam, 8	
Russell stream (three ponds)	do	2.25		
Four ponds above Spider lake	do	3		
Twenty-eight ponds		84.90		
Meduxnakeag lake	Meduxnakeag river	3.75	Dam	4
New Limerick (three ponds)	do	1.50	Dams	
Caldwell lake	do	1		
Spalding's lake	do	2.25		
No. 9 lake	do	1		
B. lake	do	1		
Eight lakes		10.50		

Name.	Connected with—	Approximate area.	Storage (1869).	Additional storage feasible.
		Sq. miles.	*Feet.*	*Feet.*
Cleaveland, or Long lake	Fish river	19		
Second, or Bear lake	do	2		
Cross, or Preble lake	do	6		
Square, or Sedgwick lake	do	15		
Eagle, or Winthrop lake	do	22		
Saint Froid, or Long lake	do	5.50		
Portage lake	do	8.50		
Fish River lake	do	7		
Ponds northwest of Spruce lake	do	1		
The Long ponds in No. 17, R. 6	do	1.25		
Five ponds above Fish River lake	do	2.75		
Fifteen lakes		89.00		
Three ponds in No. 15, R. 7	Saint John river	1.50		
Glazier's lake	do	3	6	(*c*)
Beau lake	do	5	4	(*c*)
Pohenagamook lake	do	4.50		(*c*)
Cascade Brook lake	do	2.75		
Cascade Brook upper lake	do	1		
Chimenticook lake	do	4.50		
Depot lake	do	3.50		
Ishaeganalshegeck lake	do	1.75		
Baker lake	do	4	Dam	
Francis lake	do	0.90		
Lake north of Francis lake	do	1		
Turner brook lake	do	1.10		
Woboostook lake	do	2.50		
Upper Woboostook lake	do	1		
Two lakes in No. 4, R. 17	do	2.25		
Nineteen lakes		36.65		

a Formerly a 21-foot dam. *b* Formerly several feet. *c* Several feet.

The foregoing one hundred principal lakes and ponds cover 278 square miles. The total number of lakes in the basin is 206, covering 350 square miles. It has already been remarked that some 36 square miles of lake surface naturally belonging to the Saint John have, by artificial means, been made tributary to the Penobscot. It is, however, probable that a number of small lakes and ponds in the wild parts of the basin are not represented on any map, so that the area of lake surface is, perhaps, even greater than stated above.

The rainfall over the basin of the Saint John in Maine averages about 38 inches, 10 in every season except spring, when the fall is only about 8 inches.

The greater part of the valley of the Saint John is exceedingly inaccessible, lying far removed from roads or railroads. The main river is followed quite closely by a railroad from Frederickton, New Brunswick, up to Edmunston, on the northern boundary of Maine, but with this exception no railroad penetrates the basin. The water-powers are therefore little known and will be long undeveloped, and a bare mention of the more important ones will be quite sufficient for the purposes of this report.

The census returns show but one mill in Maine on the river; there are, however, a few falls which may be named: Fish River rapids, about a mile below the mouth of the Fish river, is said to be a good site, a fall of 16 feet being available, and the bed and banks favorable for utilization. No other site is mentioned below the mouth of the Saint Francis, but above that point several are named. There are said to be two in township No. 13, range 14; one in No. 14, range 14; two in No. 12, range 15; one in No. 13, range 15; several in No. 11, range 16; and three in No. 12, range 16. These powers are unimproved, inaccessible, little known, and of small value at the present time.

TRIBUTARIES OF THE SAINT JOHN RIVER.—Of the tributaries of the Saint John, the first which offers any power in Maine is the *Meduxnekeag river*, which drains about 427 square miles in Maine, and affords a number of sites, improved only to a small extent.

The *Presque Isle river* drains 209 square miles in Maine, and also affords some powers, partially improved.

The principal tributary of the Saint John in Maine is the *Aroostook river*, which drains about 2,550 square miles in all, and about 2,500 in Maine. Rising at an elevation of about 1,050 feet, the stream falls, in its course of about 117 miles, to an elevation of 345 feet at the state line, making an average fall of about 6 feet per mile, or much greater than that of the Saint John. The stream affords a number of powers, of which Wells mentions several,

but none of great importance. The census returns show no power utilized on the stream. Its tributaries likewise afford many powers, mostly unutilized. In accordance with the general character of the country, none of the falls are extensive or precipitous, but are generally rapids, extending over some distance.

The *Fish river*, the outlet of an extensive chain of lakes, affords at Fish River mills, 1 mile above its mouth, a fall of 18 feet. The extensive reservoirs above make this stream one of the best in the whole drainage basin, and its power could be much improved. There are other powers on the river, notably two in Wallagras plantation, one with a fall of 20 feet, and the other at the outlet of Eagle lake, a little above, where a dam could be built, raising the lake.

The *Allaguash river* is the second largest tributary of the Saint John in Maine, draining about 1,650 square miles. Rising in the northern part of Piscataquis county, in Chamberlain lake, it flows nearly northward for a distance of about 60 miles, measured in a straight line, falling 308 feet, or, according to Wells, a little over 3 feet per mile. A number of powers occur about its headwaters, possessing at least the merit of constancy. Chamberlain lake is dammed to a height of 12 feet, forming a considerable reservoir, while above the lake, in township No. 8, range 13, are several precipitous falls, one of 15 feet and others smaller, the stream, however, being small. In township No. 10, range 12, there is a series of rapids on the main stream, with a total fall of 45 feet in a mile or less. No other falls are mentioned in the remainder of the course of the stream, or for 45 miles in a straight line. The census returns show no power used on the river.

The *Saint Francis river*, which enters the Saint John from the north, and forms the remainder of the northern boundary of the state of Maine, is said to afford a good power at its mouth, with an available fall of 30 feet.

The *Woonastook*, by which name the Saint John is known above its confluence with the Saint Francis, is a stream similar to the Allaguash, and its powers have already been noticed. On many of its tributaries are found rapids, but no powers of much value, for the present at least.

It is evident, from what has preceded, that the power in the basin of the Saint John is smaller in amount and less in value than that in any other large drainage basin of the state. Not only are the streams comparatively sluggish and the ledges of rock little exposed, but the inaccessibility of the district alone is sufficient to render almost valueless any powers which may exist. The day may come when these streams may be developed as sources of power, and a large amount of power could be obtained from them, and power which would be reliable throughout the year, but many years must elapse before any industries, except the lumbering, seek this region.

In regard to the state of Maine as a whole, one cannot fail to realize that the resources of the state are remarkable as regards both the amount and the constancy of its power. As its industries develop, its water-power must receive increased attention.

Summary of drainage areas of the rivers of Maine.

Stream.	Tributary to what.	Above what place.	Drainage area.
			Sq. m.
Mousam river	Atlantic ocean	Mouth	157
Do	do	Kennebunk	150
Saco river	do	Mouth	1, 753
Do	do	Saco and Biddeford	1, 734
Do	do	Union Falls	1, 677
Do	do	Salmon Falls	1, 628
Do	do	Bonny Eagle Falls	1, 578
Do	do	Highland rips	1, 366
Do	do	Great Falls	856
Do	do	Fryeburg	439
Little Ossipee river	Saco river	Mouth	158
Great Ossipee river	do	do	470
Do	do	Kezar Falls	430
Do	do	Effingham falls	340
Bear Camp river	Great Ossipee river	Mouth	157
Upper Kezar river	Saco river	do	129
East branch of	do	do	39
Presumpscot river	Atlantic ocean	do	726
Do	do	Saccarappa	546
Do	do	Outlet of lake	498
Yarmouth river	do	Mouth	164
Androscoggin river	do	Brunswick	3, 698
Do	do	Lisbon	3, 659
Do	do	Lewiston	3, 120
Do	do	Turner Centre falls	3, 070
Do	do	Turner	2, 856
Do	do	Livermore Falls	2, 689
Do	do	Jay falls	2, 664
Do	do	Capen's rips	2, 635
Androscoggin river	Atlantic ocean	Rumford Falls	2, 223
Do	do	Gorham	1, 529
Do	do	Berlin falls	1, 477
Little Androscoggin river	Androscoggin river.	Mouth	381
Do	do	Mechanics' Falls	270
Twenty-Mile river	do	Mouth	189
Sabattus river	do	do	100 ±
Dead river	do	do	138 ±
Webb's river	do	do	169
Swift river	do	do	....
Ellis river	do	do	175
Wild river	do	do	66
Outlet of chain of lakes	do	do	760
Magalloway river	do	do	416
Kennebec river	Atlantic ocean	do	6, 404
Do	do	Augusta	5, 907
Do	do	Waterville (without Sebasticook).	4, 475
Do	do	Kendall's Mills	4, 467
Do	do	Somerset Mills	4, 459
Do	do	Skowhegan	4, 176
Do	do	Norridgewock	4, 137
Do	do	Madison	3, 439
Do	do	Caratunk falls	2, 970
Do	do	Moxie rips	1, 453
Do	do	Outlet of Moosehead lake.	1, 296
Cobbosseecontee river	Kennebec river	Mouth	292
Emerson stream	do	do	a 185

a Wells.

Summary of drainage areas of the rivers of Maine—Continued.

Stream.	Tributary to what.	Above what place.	Drainage area.
			Sq. m.
Sandy river	Kennebec river	Mouth	666
Do	do	Dickerson's rips	603
Do	do	North Sharon	577
Do	do	Farmington Falls	482
Carrabasset river	do	Mouth	366
Dead river	do	do	1,021
Wesserunsett river	do	do	167
Sebasticook river	do	do	1,088
Do	do	Lower falls	996
Do	do	Hunter's Mills	887
(No name)	Sebasticook river	Mouth	186
Do	do	do	376
Sheepscot river	Atlantic ocean	do	248
Damariscotta river	do	do	40
Medomac river	do	do	118
Saint George river	do	do	228
Penobscot river	do	do	8,785
Do	do	Bangor	7,898
Do	do	Orono	7,846
Do	do	Oldtown	7,329
Do	do	Mouth of Passadumkeag	7,166
Do	do	Mouth of Piscataquis	5,202
Do	do	Island rips	4,962
Do	do	Grand Falls	3,375
Do	do	Rippogenus falls	1,512
Do	do	Pine Stream rips	835
Marsh river	Penobscot river	Mouth	156
Sowadabscook river	do	do	166
Kenduskeag river	do	do	229
Pushaw river	do	do	231
Passadumkeag river	do	do	402
Piscataquis river	do	do	1,541
Do	do	Maxfield	1,359
Do	do	Medford	1,251
Do	do	Mouth of Pleasant river	792
Do	do	Dover village	387
Seboois river	Piscataquis river	Mouth	175
Outlet of Schoodic lake	do	do	58
Pleasant river	do	do	434
Sebec river	do	do	298
Do	do	do	270
Mattawamkeag river	Penobscot river	do	1,533
Do	do	Slugundy falls	1,446
Molunkus river	Mattawamkeag river.	Mouth	273
Baskahegan river	do	do	214
North branch of	do	do	183
South branch of	Mattawamkeag river.	Mouth	326
Salmon river	Penobscot river	do	116
East branch of	do	do	922
Outlet of Seboois lakes	East branch Penobscot river.	do	304
Millinoket river	Penobscot river	do	171
Cancomgomock river	do	do	234
Middle branch of	do	do	244
South branch of	do	do	206
Union river	Atlantic ocean	do	584
North branch of	Union river	do	214
South branch of	do	do	145
Narraguagus river	Atlantic ocean	do	260
Pleasant river	do	do	106
West Machias river	do	do	458
Do	do	Whitney	436
Do	do	Centreville	419
Do	do	Northfield	402
East Machias river	do	Mouth	345
Denny's river	do	do	158
Saint Croix river	do	Calais (Union falls)	1,674
Do	do	Baring	1,511
Do	do	Sprague's Falls	1,496
Do	do	Junction of two branches	1,400
Chiputneticook river	Saint Croix river	do	634
Do	do	Rocky rips	518
Do	do	Vanceborough	437
Saint Croix river	Atlantic ocean	In Maine, above Calais	1,102
Do	do	In New Brunswick, above Calais.	672
Schoodic or Kennebasis river.	Saint Croix river	Mouth	706
Do	do	Mouth of Long lake	583
Saint John river	Atlantic ocean	In Maine	7,998
Meduxnekeag river	Saint John river	Mouth	562
Do	do	In Maine	427
Presque Isle river	do	do	209
Aroostook river	do	Mouth	2,556
Do	do	In Maine	2,498
Do	do	Mesardis	926
Little Madawaska river	Aroostook river	Mouth	232
Great Machias river	do	do	378
Fish river	Saint John river	do	938
Do	do	Fish River mills	910
Do	do	Outlet of Eagle lake	815
Allaguash river	do	Mouth	1,648
Woonastook river	do	Total above mouth of Little Black river.	2,741

Table of power utilized on the coast streams of Maine.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Mousam river	Atlantic ocean	Maine	York	Woolen	2	24	210
Do	do	do	do	Cotton	2	28	225
Do	do	do	do	Boots and shoes	1	17	30
Do	do	do	do	Boot and shoe findings	1	24	200
Do	do	do	do	Sash, door, and blind	1	10	52
Do	do	do	do	Flour and grist	3	32	90
Do	do	do	do	Saw	5	53	196
Tributaries of the	Mousam river	do	do	Flour and grist	2	41	100
Do	do	do	do	Saw	5	91	285
Kennebunk river	Atlantic ocean	do	do	do	3	32	104

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Saco river	Atlantic ocean	Maine	York	Cotton	3	64	4,600
Do	do	do	do	Woolen	1	10	50
Do	do	do	do	Foundery	1	6	12
Do	do	do	do	Flour and grist	3	30	150
Do	do	do	do	Saw	11	145	750
Do	do	do	do	Cotton and woolen machinery	1	16	100
Do	do	do	Cumberland	Flour and grist	1	12	50
Do	do	do	do	Saw	2	24	145
Do	do	do	Oxford	do	1	9	50
Do	do	do	do	Wheelwrighting	1	11	6
Little Ossipee river	Saco river	do	York	Foundery	1	10	30
Do	do	do	do	Leather-board	1	18	100
Do	do	do	do	Flour and grist	2	18	88
Do	do	do	do	Saw	5	49	200
Do	do	do	do	Woolen	1	12	120
Great Ossipee river	do	do	do	Flour and grist	1	8	45
Do	do	do	do	Saw	3	34	80
Do	do	New Hampshire	Carroll	Blacksmithing	1	11	12
Do	do	do	do	Woolen	1	9	30
Do	do	do	do	Flour and grist	1	7	40
Do	do	do	do	Saw	4	55	120
Other tributaries	Atlantic ocean	Maine	York	Furniture	1	16	30
Do	do	do	do	Tannery	1	14	14
Do	do	do	do	Wheelwrighting	2	22	17
Do	do	do	do	Carriages and wagons	1	10	5
Do	do	do	do	Flour and grist	5	73	104
Do	do	do	do	Saw	23	261	599
Do	do	do	do	Woolen	2	......	78
Tributaries of the	Saco river	New Hampshire	Carroll	Woolen	4	......	48
Do	do	do	do	Boxes	1	10	8
Do	do	do	do	Carriages and wagons	1	7	20
Do	do	do	do	Excelsior	2	21	55
Do	do	do	do	Furniture	2	37	48
Do	do	do	do	Planing	2	64	40
Do	do	do	do	Tannery	1	8	25
Do	do	do	do	Flour and grist	4	61	145
Do	do	do	do	Saw	24	368	806
Do	do	do	do	Paper	1	11	30
Do	do	do	do	Sash, door, and blind	1	11	12
Do	do	do	do	Spool and bobbin	3	38	79
Do	do	do	do	Wheelwrighting	2	29	35
Presumpscot river	Atlantic ocean	Maine	Cumberland	Silk	1	18	30
Do	do	do	do	Cotton	4	55	(?)1,000
Do	do	do	do	Flour and grist	1	16	50
Do	do	do	do	Saw	4	57	200
Do	do	do	do	Leather-board	1	16	50
Do	do	do	do	Wood-pulp	2	26	1,500
Do	do	do	do	Machinery	2	32	100
Do	do	do	do	Gunpowder	1	18	500
Do	do	do	do	Paper	1	20	2,000
Androscoggin river	do	do	do	Flour and grist	1	15	30
Do	do	do	do	Saw	2	28	375
Do	do	do	do	Wood-pulp	1	14	150
Do	do	do	do	Machinery	1	15	4
Do	do	do	do	Cotton	1	16	800
Do	do	do	Sagadahoc	Paper	1	15	750
Do	do	do	do	Saw	1	14	40
Do	do	do	do	Flour and grist	1	14	60
Do	do	do	do	Sash, door, and blind	1	14	......
Do	do	do	Androscoggin	Wood-turning	2	27	150
Do	do	do	do	Leather-board	1	16	166
Do	do	do	do	Pulp	1	12	350
Do	do	do	do	Cotton and woolen machinery	1	......	2
Do	do	do	do	Shirts	2	......	10
Do	do	do	do	Bobbins and spools	1	......	12
Do	do	do	do	Lasts	1	......	10

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Androscoggin river	Atlantic ocean	Maine	Androscoggin	Printing and publishing	2		8
Do	...do	...do	...do	Belting, etc	2		100
Do	...do	...do	...do	City water-works	1	25	
Do	...do	...do	...do	Planing	2		80
Do	...do	...do	...do	Flour and grist	4		225
Do	...do	...do	...do	Saw	2	24	145
Do	...do	...do	...do	Woolen	4	61	727
Do	...do	...do	...do	Cotton	6	175	7,800
Do	...do	...do	...do	Bleachery	1	35	387
Do	...do	...do	Oxford	Coffins, etc	1	11	13
Do	...do	...do	...do	Flour and grist	1	15	15
Do	...do	...do	...do	Saw	1	15	15
Do	...do	...do	...do	Wheelwrighting	1	12	12
Do	...do	New Hampshire	Coos	Saw	2	24	710
Do	...do	...do	...do	Wood-pulp	1	24	230
Sabattus river	Androscoggin river	Maine	Androscoggin	Excelsior	1	14	18
Do	...do	...do	...do	Flour and grist	2	27	95
Do	...do	...do	...do	Woolen	4	59	226
Do	...do	...do	...do	Saw	3	39	135
Do	...do	...do	...do	Cotton	1	30	300
Little Androscoggin river	...do	...do	...do	Wooden boxes	1	14	40
Do	...do	...do	...do	Paper	1	34	
Do	...do	...do	...do	Flour and grist	2	36	90
Do	...do	...do	...do	Saw	2	23	130
Do	...do	...do	...do	Cotton	1	35	400
Do	...do	...do	Oxford	Woolen	1	9	40
Do	...do	...do	...do	Wooden-ware	1	8	25
Do	...do	...do	...do	Paper-box board	1	24	175
Do	...do	...do	...do	Saw	2	18	60
Twenty-Mile river	...do	...do	Androscoggin	Wheelwrighting	1	9	20
Do	...do	...do	...do	Flour and grist	2	26	80
Do	...do	...do	...do	Saw	3	33	78
Do	...do	...do	...do	Woolen	1	9	33
Do	...do	...do	Oxford	Saw	1	9	35
Webb's river	...do	...do	...do	Wood-turning	1	14	45
Do	...do	...do	...do	Brick and tile	1		2
Do	...do	...do	...do	Flour and grist	1	16	40
Do	...do	...do	Franklin	...do	1	9	17
Do	...do	...do	...do	Saw	2	24	125
Do	...do	...do	...do	Wooden boxes	1	9	25
Swift river	...do	...do	Oxford	Saw	1	16	60
Ellis river	...do	...do	...do	Starch	2	21	38
Do	...do	...do	...do	Flour and grist	1	12	18
Do	...do	...do	...do	Saw	1	12	15
Other tributaries of the	Coast streams of Maine	...do	Cumberland	Flour and grist	18	217	755
Do	...do	...do	...do	Saw	51	689	1,579
Do	...do	...do	...do	Boots and shoes	1		23
Do	...do	...do	...do	Wooden-ware	1	12	45
Do	...do	...do	...do	Washing machines and clothes wringers.	1	12	12
Do	...do	...do	...do	Stone and earthen ware	1	6	8
Do	...do	...do	...do	Wood-pulp	1	19	80
Do	...do	...do	...do	Carriage and wagon material	1	16	30
Do	...do	...do	...do	Wooden boxes	2	17	30
Do	...do	...do	...do	Machinery	1	14	23
Do	...do	...do	...do	Cooperage	4	75	117
Do	...do	...do	...do	Furniture	1	22	90
Do	...do	...do	...do	Woolen	5	41+	247
Do	...do	...do	...do	Cotton	3		176
Do	...do	...do	Androscoggin	Cooperage	1	30	25
Do	...do	...do	...do	Machinery	1		30
Do	...do	...do	...do	Carriages and wagons	1	10	25
Do	...do	...do	...do	Flour and grist	9	125	276
Do	...do	...do	...do	Saw	19	230	564
Do	...do	...do	...do	Furniture	1	10	20
Do	...do	...do	...do	Woolen	2		30

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of the	Coast streams of Maine	Maine	Oxford	Woolen	6		......
Do	do	do	do	Agricultural implements	2	19	60
Do	do	do	do	Boot and shoe findings	1	11	30
Do	do	do	do	Wooden boxes	2	21	50
Do	do	do	do	Carpentering	1	9	60
Do	do	do	do	Coffins, etc	1	13	40
Do	do	do	do	Cooperage	2	18	20
Do	do	do	do	Flour and grist	16	215	579
Do	do	do	do	Furniture	5	51	58
Do	do	do	do	Chairs	1	9	18
Do	do	do	do	Wooden bandles	4	46	133
Do	do	do	do	Iron castings	1	12	45
Do	do	do	do	Leather goods	1	10	150
Do	do	do	do	Tanneries	2	25	32
Do	do	do	do	Saw	61	760	1,762
Do	do	do	do	Sash, door, and blind	1	15	15
Do	do	do	do	Wheelbarrow	1	20	30
Do	do	do	do	Wheelwrighting	4	36	53
Do	do	do	do	Wood-turning	1	12	12
Do	do	do	do	Wooden ware	2	24	37
Do	do	New Hampshire	Coos	Saw	1	10	20
Do	do	do	do	Flour and grist	4	39	80
Kennebec river	Atlantic ocean	Maine	Kennebec	Cotton	2	37	(?)2,500
Do	do	do	do	Furniture	1	15	200
Do	do	do	do	Flour and grist	1	22	150
Do	do	do	do	Saw	1	16	200
Do	do	do	Somerset	Woolen	1	13	84
Do	do	do	do	Wooden boxes	1	7	80
Do	do	do	do	Cutlery	4	......	135
Do	do	do	do	Coffins	1	......	13
Do	do	do	do	Flour and grist	4	50	250
Do	do	do	do	Wooden handles	1	13	20
Do	do	do	do	Kaolin, etc	1	12	55
Do	do	do	do	Furniture	1	7	100
Do	do	do	do	Planing	1	7	80
Do	do	do	do	Saw	10	104	1,045
Do	do	do	do	Machinery	1	8	18
Do	do	do	do	Wheelwrighting	1	15	35
Do	do	do	do	Paper	1	10	100
Do	do	do	do	Sash, door, and blind	4	43	125
Do	do	do	do	Starch	1	9	25
Do	do	do	do	Wooden ware	2	......	100
Do	do	do	do	Wood-pulp	1	9	83
Do	do	do	do	Wood-turning	1	......	6
Cobbosseecontee river	Kennebec river	do	Kennebec	Paper boxes	1	16	45
Do	do	do	do	Carpentering	1	14	19
Do	do	do	do	Furniture	2	28	40
Do	do	do	do	Flour and grist	2	27	105
Do	do	do	do	Tanneries	2	18	32
Do	do	do	do	Foundery	1	11	15
Do	do	do	do	Machinery	2	21	34
Do	do	do	do	Paper, wrapping	1	13	300
Do	do	do	do	Paper, printing	1	17	225
Do	do	do	do	Paper, colored	1	16	480
Do	do	do	do	Saw	6	74	720
Do	do	do	do	Steel springs	1	15	100
Do	do	do	do	Sash, door, and blind	2	30	44
Do	do	do	do	Wood-turning	1	15	38
Do	do	do	do	Woolen	1	11	50
Emerson stream	do	do	do	Agricultural implements	4	50	605
Do	do	do	do	Carpentering	1	8	90
Do	do	do	do	Chairs	1	8	15
Do	do	do	do	Flour and grist	1	8	40
Do	do	do	do	Wooden handles	1	5	25
Do	do	do	do	Tanneries	2	18	68
Do	do	do	do	Matches	1	8	10

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Emerson stream	Kennebec river	Maine	Kennebec	Machinery	1	8	60
Do	do	do	do	Saw	1	12	50
Do	do	do	do	Sash, door, and blind	2	22	140
Do	do	do	do	Wheelwrighting	1	8	10
Sebasticook river	do	do	do	Boot and shoe findings	1	10	24
Do	do	do	do	Flour and grist	1	7	200
Do	do	do	do	Tannery	1	12	12
Do	do	do	do	Saw	4	38	337
Do	do	do	do	Wood-pulp	1	16	270
Do	do	do	Somerset	Blacksmithing	3	12	20
Do	do	do	do	Flour and grist	2	18	90
Do	do	do	do	Furniture	1	10	20
Do	do	do	do	Saw	6	45	150
Do	do	do	do	Tanneries	2	20	100
Do	do	do	do	Wheelwrighting	1	7	10
Do	do	do	do	Woolen	3	26	118
Do	do	do	Waldo	Saw	1	14	20
Do	do	do	Penobscot	Flour and grist	2	23	62
Do	do	do	do	Saw	4	42	150
Do	do	do	do	Machinery	1	10	25
Sandy river	do	do	Franklin	Flour and grist	2	25	75
Do	do	do	do	Saw	4	50	125
Do	do	do	do	Wooden handles	1	7	20
Do	do	do	do	Upholstering materials	1	8	25
Do	do	do	do	Wood-turning	1	8	20
Do	do	do	do	Furniture	1	7	12
Seven-Mile (or Carrabasset) river	do	do	do	Flour and grist	1	8	10
Do	do	do	do	Saw	3	25	90
Do	do	do	do	Agricultural implements	1	11	10
Do	do	do	Somerset	Flour and grist	1	50	90
Do	do	do	do	Saw	4	94	320
Do	do	do	do	Tannery	1	8	8
Do	do	do	do	Woolen	1	10	25
Dead river	do	do	do	Flour and grist	1	10	12
Do	do	do	do	Saw	1	8	6
Do	do	do	Franklin	Flour and grist	1	12	24
Do	do	do	do	Saw	1	10	33
Sheepscot river	Atlantic ocean	do	Lincoln	Woolen	1	8	24
Do	do	do	do	Flour and grist	5	59	202
Do	do	do	do	Saw	12	120±	357
Do	do	do	Waldo	do	4	30+	53
Damariscotta river	do	do	Lincoln	Flour and grist	1	15	40
Do	do	do	do	Saw	1	10	40
Medomac river	do	do	do	Flour and grist	3	....	44
Do	do	do	do	Foundery	1	....	8
Do	do	do	do	Marble and stone work	1	....	8
Do	do	do	do	Saw	4	47	65
Do	do	do	do	Planing	1	25	25
Do	do	do	do	Woolen	1	5	8
Saint George river	do	do	Knox	do	1	10	40
Do	do	do	do	Carriages and wagons	1	8	25
Do	do	do	do	Flour and grist	2	21	42
Do	do	do	do	Saw	4	42	51
Do	do	do	do	Tanneries	2	24	90
Do	do	do	do	Wheelwrighting	2	....	16
Do	do	do	Waldo	Woolen	1	12	15
Do	do	do	do	Tanneries	2	28	50
Do	do	do	do	Foundery	1	10	6
Do	do	do	do	Wood-turning	1	12	10
Do	do	do	do	Cutlery	1	8	15
Do	do	do	do	Flour and grist	2	33	40
Do	do	do	do	Saw	9	97	181
Do	do	do	do	Sash, door, and blind	1	6	15
Penobscot river	do	do	Penobscot	Flour and grist	2	24	65
Do	do	do	do	Saw	21	223	5,719
Do	do	do	do	Machinery	1	8	30

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Marsh river	Penobscot river	Maine	Waldo	Flour and grist	5	68	154
Do	do	do	do	Woolen	1	10	28
Do	do	do	do	Saw	6	75	153
Sowadabscook river	do	do	Penobscot	Paper, printing	1	12	75
Do	do	do	do	Paper, wrapping	1	18	120
Do	do	do	do	Woolen	1	9	8
Kenduskeag river	do	do	do	Wood-turning	1	12	40
Do	do	do	do	Wheelwrighting	1	10	40
Do	do	do	do	Flour and grist	7	79	319
Do	do	do	do	Saw	16	163	606
Do	do	do	do	Salt, ground	2	18	85
Do	do	do	do	Plaster, ground	2	18	85
Great Works river	do	do	do	Saw	1	12	40
Pushaw river	do	do	do	Furniture	1	7	15
Do	do	do	do	Saw	1	7	50
Piscataquis river	do	do	Piscataquis	Agricultural implements	1	10	15
Do	do	do	do	Blacksmithing	1	8	3
Do	do	do	do	Furniture	1	12	15
Do	do	do	do	Foundery	1	10	15
Do	do	do	do	Flour and grist	4	58	225
Do	do	do	do	Tannery	1	12	20
Do	do	do	do	Saw	8	94	553
Do	do	do	do	Sash, door, and blind	1	10	15
Do	do	do	do	Wheelwrighting	3	31	10
Do	do	do	do	Woolen	4	56	186
Sebec river	Piscataquis river	do	do	Flour and grist	2	22	45
Do	do	do	do	Woolen	1	10	24
Do	do	do	do	Tannery	1	14	25
Do	do	do	do	Woolen	1	10	15
Do	do	do	do	Saw	3	40	92
Do	do	do	do	Wheelwrighting	1	6	6
Pleasant river	do	do	do	Flour and grist	1	12	22
Do	do	do	do	Saw	1	12	30
Do	do	do	do	Wheelwrighting	1	12	6
Do	do	do	do	Wood-turning	1	9	12
Do	do	do	do	Blast-furnace	1	14	185
Mattawamkeag river	Penobscot river	do	Aroostook	Saw	1	6	20
Union river	Atlantic ocean	do	Hancock	Tannery	1	14	20
Do	do	do	do	Saw	14	139	1,900
Narraguagus river	do	do	Washington	Furniture	1	7	25
Do	do	do	do	Sash, door, and blind	1	7	20
Do	do	do	do	Flour and grist	1	7	20
Do	do	do	do	Saw	5	53	435
East and West Machias rivers	do	do	do	do	10	89	820
Saint Croix river	do	do	do	Machinery	1	8	30
Do	do	do	do	Woolen	1	6	12
Do	do	do	do	Saw	3	32	320
Do	do	do	do	Tannery	1	8	200
Kennebasis river	Saint Croix river	do	do	do	2	....	135
Do	do	do	do	Saw	1	10	75
Saint John river	Atlantic ocean	do	Aroostook	do	1	12	9
Meduxnekeag river	Saint John river	do	do	Flour and grist	3	33	173
Do	do	do	do	Saw	9	89	480
Do	do	do	do	Starch	1	8	10
Do	do	do	do	Sash, door, and blind	1	10	20
Do	do	do	do	Plaster	1	10	20
Do	do	do	do	Furniture	1	10	15
Do	do	do	do	Tannery	1	11	75
Fish river	do	do	do	Flour and grist	1	18	30
Do	do	do	do	Saw	1	18	30
Other streams	Atlantic ocean	do	Sagadahoc	Fertilizers	1	6	15
Do	do	do	do	Flour and grist	1	6	15
Do	do	do	do	Kaolin and ground earths	1	12	28
Do	do	do	do	Plaster, ground	1	6	15
Do	do	do	do	Saw	22	173	660
Do	do	do	Franklin	Flour and grist	5	72	94

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Table of power utilized on the coast streams of Maine—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other streams	Atlantic ocean	Maine	Franklin	Saw	28	329	626
Do	do	do	do	Carriages and wagons	1	10	20
Do	do	do	do	Agricultural implements	2	30	120
Do	do	do	do	Wooden handles	1	12	20
Do	do	do	do	Planing	1	7	15
Do	do	do	do	Upholstering materials	1	8	10
Do	do	do	do	Woolen	2	25	95
Do	do	do	do	Wood-turning	2	21	120
Do	do	do	do	Tanneries	2	12	40
Do	do	do	do	Boots and shoes	2	12	20
Do	do	do	do	Wheelwrighting	1	15	8
Do	do	do	Kennebec	Agricultural implements	7	102	624
Do	do	do	do	Blacksmithing	1	6	15
Do	do	do	do	Paper boxes	2	......	8
Do	do	do	do	Wooden boxes	1	6	50
Do	do	do	do	Boot and shoe findings	1	11	25
Do	do	do	do	Coffins, etc	1	18	20
Do	do	do	do	Flour and grist	18	215	663
Do	do	do	do	Wooden handles	1	11	30
Do	do	do	do	Tanneries	4	61	70
Do	do	do	do	Founderies	3	44	44
Do	do	do	do	Machinery	2	27	28
Do	do	do	do	Paper	2	27	555
Do	do	do	do	Saw	29	337	1,400
Do	do	do	do	Upholstering materials	2	23	55
Do	do	do	do	Shoddy	1	12	20
Do	do	do	do	Sash, door, and blind	1	10	12
Do	do	do	do	Wood-turning	2	17	90
Do	do	do	do	Woolen	3	65	421
Do	do	do	do	Cotton	1	7	60
Do	do	do	Knox	Agricultural implements	1	15	15
Do	do	do	do	Bread, crackers, etc	1	5	10
Do	do	do	do	Cooperage	1	16	70
Do	do	do	do	Coffins	1	11	25
Do	do	do	do	Furniture	1	11	18
Do	do	do	do	Flour and grist	7	80	228
Do	do	do	do	Gunpowder	1	12	15
Do	do	do	do	Founderies	2	27	85
Do	do	do	do	Iron anchors and chains	1	9	25
Do	do	do	do	Saw	16	216	430
Do	do	do	do	Tannery	1	15	20
Do	do	do	do	Machinery	2	19	35
Do	do	do	do	Marble and stone works	2	17	70
Do	do	do	do	Musical instruments	1	12	20
Do	do	do	do	Sash, door, and blind	1	14	70
Do	do	do	do	Wheelwrighting	1	11	15
Do	do	do	do	Woolen	1	13	35
Do	do	do	Lincoln	Flour and grist	2	23	115
Do	do	do	do	Saw	14	152	337
Do	do	do	do	Woolen	1	......	5
Do	do	do	Waldo	Agricultural implements	1	12	10
Do	do	do	do	Tanneries	2	22	65
Do	do	do	do	Plaster, ground	2	40	90
Do	do	do	do	Cutlery	2	17	110
Do	do	do	do	Leather-board	1	14	100
Do	do	do	do	Flour and grist	6	75	158
Do	do	do	do	Saw	22	260	700
Do	do	do	do	Sash, door, and blind	1	7	30
Do	do	do	do	Woolen	1	12	20
Do	do	do	Somerset	Blacksmithing	3	20	27
Do	do	do	do	Wooden boxes	1	10	40
Do	do	do	do	Flour and grist	12	159	382
Do	do	do	do	Wooden handles	2	16	52
Do	do	do	do	Hardware	1	6	24
Do	do	do	do	Saw	40	445	1,230
Do	do	do	do	Tanneries	3	28	78

Table of power utilized on the coast streams of Maine—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other streams	Atlantic ocean	Maine	Somerset	Sash, door, and blind	1	8	15
Do	...do	...do	...do	Toys and games	1	14	20
Do	...do	...do	...do	Wheelwrighting	6	30+	109
Do	...do	...do	...do	Woolen	3	20	60
Do	...do	...do	Hancock	Flour and grist	11	132	239
Do	...do	...do	...do	Tanneries	2	19	72
Do	...do	...do	...do	Wood-turning	1	....	20
Do	...do	...do	...do	Woolen	7	....	108
Do	...do	...do	...do	Saw	42	476	979
Do	...do	...do	Washington	Plaster, ground	1	26	100
Do	...do	...do	...do	Marble and stone work	1	17	100
Do	...do	...do	...do	Flour and grist	8	69	178
Do	...do	...do	...do	Saw	26	222	1,165
Do	...do	...do	...do	Tannery	1	14	15
Do	...do	...do	...do	Rolling	1	30	500
Do	...do	...do	...do	Woolen	1	14	5
Do	...do	...do	Penobscot	Blacksmithing	2	28	9
Do	...do	...do	...do	Marble and stone work	1	....	3
Do	...do	...do	...do	Furniture	8	....	40
Do	...do	...do	...do	Men's clothing	1	....	20
Do	...do	...do	...do	Printing	3	....	14
Do	...do	...do	...do	Bread, crackers, etc	1	....	4
Do	...do	...do	...do	Sash, door, and blind	3	20	27
Do	...do	...do	...do	Wheelwrighting	1	10	15
Do	...do	...do	...do	Carriages and wagons	1	10	4
Do	...do	...do	...do	Flour and grist	13	164	398
Do	...do	...do	...do	Saw	47	492	1,600
Do	...do	...do	...do	Foundery	1	12	12
Do	...do	...do	...do	Tanneries	4	53	345
Do	...do	...do	...do	Brass foundery	1	....	3
Do	...do	...do	...do	Machinery	1	....	1
Do	...do	...do	...do	Locksmithing	1	....	3
Do	...do	...do	...do	Planing	1	11	15
Do	...do	...do	...do	Wooden boxes	1	14	12
Do	...do	...do	...do	Wooden-ware	1	10	47
Do	...do	...do	...do	Woolen	6	....	93
Do	...do	...do	Piscataquis	Cooperage	1	12	50
Do	...do	...do	...do	Flour and grist	4	51	65
Do	...do	...do	...do	Saw	20	238	561
Do	...do	...do	...do	Woolen	1	13	65
Do	...do	...do	Aroostook	Flour and grist	16	174	319
Do	...do	...do	...do	Saw	38	464	1,564
Do	...do	...do	...do	Starch	5	60	136
Do	...do	...do	...do	Sash, door, and blind	2	22	30
Do	...do	...do	...do	Planing	1	12	20
Do	...do	...do	...do	Plaster	1	12	30
Do	...do	...do	...do	Furniture	1	....	10
Do	...do	...do	...do	Woolen	1	....	50

INDEX TO REPORT ON THE STREAMS OF EASTERN NEW ENGLAND.

REPORT ON THE WATER-POWER

OF THE

REGION TRIBUTARY TO LONG ISLAND SOUND,

BY

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1012 W P—VOL 16——11

LETTER OF TRANSMITTAL.

BOSTON, MASS., *July* 9, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York city.

SIR: I have the honor to submit a report upon the water-power of the region tributary to Long Island sound, based upon investigations carried on, under your direction, mainly in the summer and autumn of 1882. The results presented rest largely upon personal observation, but yet more upon interviews with manufacturers, civil engineers, and other persons having definite knowledge of the streams examined. Much has also been drawn from printed reports, and information has otherwise been derived from a variety of sources. With the limited time at my disposal it was out of the question to make a thorough examination of the numerous streams in this section, closely lined as many of them are with manufacturing sites, and some of the remoter districts had to be overlooked altogether. Nevertheless, enough has perhaps been learned to fulfill the general design of the work, in so far as it is included under the following headings: First, to furnish reliable information upon the topography, resources, and other physical conditions affecting the value of the principal streams for water-power; second, to give such description of existing improvements on the streams as might be of general interest or of use in planning future works; third, and especially, to present such data as it was practicable to obtain bearing upon the opportunities for further development of power. In this connection estimates of available power have been prepared for important sites, in accordance with principles fully explained elsewhere and uniformly followed in the reports committed to my care. Courtesy and aid were almost invariably received from those consulted during the work, and are gratefully acknowledged.

Very respectfully,

DWIGHT PORTER,

Special Agent.

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METHOD EMPLOYED IN ESTIMATING THE FLOW OF STREAMS.

It will be admitted by all that the only satisfactory mode of determining the volume of a stream is by careful measurements; and that, in order that such measurements shall truthfully show its character and capacity as regards flow, they must be continued regularly for a series of years. There are a very few rivers in the United States, such as the Connecticut, Sudbury, and Croton, with some others, that have been gauged in this manner; but the great majority have not been gauged at all, and even where measurements have been made there have usually been but one or two for a stream, and these have often been rudely carried out, and without recording very definitely the accompanying stage of water.

Under these circumstances it may seem rash to attempt any extended system of estimates. I have chosen to do so, however, and mainly for the following reasons: One of the great objects of this whole work has been to show, so far as possible, what opportunities exist for the development of new water-powers, and the further utilization of old ones. A natural and leading question concerning any privilege described would be as to the available power, and it is a question to which an answer only approximately correct is much better than none at all. A mere description of a stream stating that it is a certain number of feet wide and a certain number deep, that it has a swift or a sluggish current, and that it is well or poorly sustained in the dry season, conveys but a meager and indefinite idea as to its real capacity. Again, very erroneous views are frequently held and given out as to the power to be obtained at certain points. Not once only, but many times, it has been represented to me, with half honesty, that some privilege would carry "more machinery than is found at Lowell", or "all the machinery that could be placed upon it", while it was evident that the power was really quite limited. What is vaguely called the "average stage" of a stream is sometimes used as the basis for calculating its power, though it is manifestly an unfair basis. Although I recognize that the results of my estimates are liable to wide errors, and although I wish here to disclaim for them a pretension of accuracy, yet, in view of the facts I have stated, I think they may have a value in roughly indicating the available power of the various streams. I have endeavored to form them with care and discrimination; to obtain the best data possible; to compare the streams with each other; to adjust the results to actual measurements, where those have been made, rather than trust entirely to theory; and, especially, to place them under, rather than over, the truth.

These estimates will generally be found given for the following stages of flow:

1. *Low water of an ordinarily dry year.*
2. *Low water of an average year.*
3. *Available ten months in an average year.*

In using the term low water as above, I make exception of the abnormally low stage which a stream will sometimes reach, and maintain for some hours, or even a day or two, and which is due to the temporary shutting down at points above to permit mill-ponds to fill.

By an ordinarily dry year, I mean such an one as is likely to occur in the course of five or ten years. At longer intervals, ranging from ten to fifty years, remarkable droughts may occur, when a stream will sink still lower and reach its minimum, but such an occurrence is so exceptional that it need not here be considered.

Making the same exception as before for abnormally low flow, low water of an average year would, if gaugings were at hand, be determined as the average of the lowest gaugings of each of a series of years.

The third estimate is for the volume to be relied upon ten months in the average of years. Those ten months need not be consecutive; they express the sum total of the time during which the volume will be above a certain point, and include the period of high water, in which more or less hinderance, and even stoppage, are liable from

backwater. It is very seldom that an important privilege is developed to a degree that can be realized only a few months in the year; but it is common to introduce wheels of a capacity for which the supply of water will suffice only nine or ten months, and it seems fitting that a corresponding estimate should be made.

In all cases, unless otherwise stated, the volume of a stream as given by me must be regarded as the average flow for twenty-four hours. By storage at dams during the night, and use of power in the day-time only, the flow can be concentrated and more than the average discharge realized during the working hours. But I have few data as to the extent of pondage that could be obtained; and the effects of storage, in varying amounts and at different points along a stream, are so intermingled that I think it impracticable to attempt estimates in which that item shall be taken into account. The calculated horse-powers are gross, or theoretical; from 60 to 80 per cent. of their amount will be yielded by good turbine-wheels.

The method employed by me in constructing my estimates involves two general assumptions:

1. A certain proportion of the mean annual rainfall as carried off, in the average of years, by each stream.
2. A certain distribution of that drainage through the year.

Both the assumed proportion and its distribution vary with the stream; the general reasons which act to change these conditions, such as topography, character of rainfall, lakes, forests, and other causes, are so well-known, and have been so often stated, that I shall not rehearse them here. With regard to the first assumption, it may be said, in brief, that a large proportional discharge will be promoted by a prompt and thorough drainage of the rainfall into the water-courses; and that, generally speaking, those causes which are opposed to such a drainage will tend to produce a lower proportional discharge. The two qualities of promptness and thoroughness do not, however, always occur in the same degree, but vary widely with the surface and other conditions, and each may act to disguise, and even to overcome, an effect of the other: For example, other things remaining the same, from a steep, rocky district, with a scanty covering of soil, and devoid of forests, the introduction of the latter might result in a smaller annual drainage; but their introduction upon a flat region might increase the annual drainage by sheltering the surface of the ground and so diminishing evaporation; in other words, while in the latter case lessening the promptness of drainage, they might, to a much greater extent, increase its completeness.

In assuming the proportion of rainfall discharged by the streams, I have been guided by such published data as I was able to find. They are as follows:

A.—Connecticut river, at Hartford. For the eight years, 1871–'78, the discharge of this river was observed daily, under the direction of Mr. Theodore G. Ellis, civil engineer. The observations were made for the government, in the interests of navigation. The daily record for the years 1871–'77, both inclusive, is contained in *Ex. Doc. No.* 101, *House of Rep.*, 45*th Congress*, 2*d session. House Ex. Doc. No.* 42, 46*th Congress*, 2*d session*, contains the daily record for 1878, and also a summary of the discharge by months for the whole eight years. The drainage area above Hartford, as given by Mr. Clemens Herschel, is 10,234 square miles (see *Transactions Amer. Soc. Civ. Engrs.*, Vol. VII, No. clxviii). From the Smithsonian rainfall records I find the average rainfall over this section to be approximately 42.7 inches. Of this rainfall a mean annual percentage of 62.8 was discharged by the river; in the year of maximum discharge the percentage of the mean annual rainfall was 72.2, while in the minimum year it was 51.8. The area drained by the Connecticut is hilly and mountainous, the valleys being more or less cultivated, and the hills wooded and pasture land.

B.—Sudbury river, Massachusetts. In a paper by Mr. Alphonse Fteley (see *Transactions Amer. Soc. Civ. Engrs.*, Vol. X, No. ccxxiv) are given the results of a very careful series of gaugings of this river, extended through the six years 1875–'80, from which it appears that of a mean annual rainfall during that period of 46.1 inches, an average of 47.56 per cent. was collected by the stream.

Comparing the amount collected in any one year with the rainfall in the same year, the maximum percentage was 57.90 and the minimum 32.71.

Comparing the amount collected in any one year with the mean rainfall for the entire six years, the maximum percentage was 66.13 and the minimum 27.09. The drainage area included in these observations was 78 square miles, described as one-sixth to one-eighth wooded, and the balance farming land.

C.—See *Transactions Amer. Soc. Civ. Engrs.*, Vol. III, No. lxxxvii, *Notes on the Flow of the West Branch of the Croton River*—J. James R. Croes. As a mean from observations for 49½ months, it appears that the annual rainfall during the time, upon the basin of the West branch of the Croton river, was 50 inches, of which an average of 62.92 per cent. was discharged by the stream. The drainage area was 20.37 square miles. Regarding the surface features, Mr. Croes remarks:

> The surface of this water-shed is very broken and undulating, the hill-sides are steep and rocky, a large proportion of the area is covered with timber, and of the cleared portion the greater part is kept in grass, very little being cultivated. The rock, which lies near the surface over most of the area, is a very compact gneiss.

In the same paper is given the proportional discharge from the entire water-shed of the Croton river, from which the supply of New York city is drawn. "This water-shed includes that of the West branch, but is sixteen

times as great, comprising 335 square miles. The proportion of flat and cultivated land is much greater." The discharge was not determined with as great accuracy as in the case of the West branch, but showed as the average of six years (1864–'69) a rainfall of 49.79 inches, of which 50.5 per cent. was carried off by the stream.

D.—In the report for the quarter ending June 30, 1879, of the Department of Public Works, New York city, is given the average daily flow of the Croton river at Croton dam for the thirteen years 1866–'78.

The drainage area is here stated as 339 square miles. The average annual rainfall during the period was 46.64 inches, of which the mean drainage by the stream was 56.5 per cent.

Comparing the drainage in any one year with the rainfall in the same year, the maximum ratio was 0.74, and the minimum 0.45.

Comparing the drainage in any one year with the mean rainfall for the whole thirteen years, the maximum ratio was 0.80, and the minimum 0.41.

E.—In a report by Captain Charles J. Allen, corps of engineers, U. S. Army, on the subject of reservoirs at the sources of the Mississippi (*Senate Ex. Doc. No.* 48, *46th Congress*, *3d session*), there is given a table, copied from a report of the Boston water-board, showing the rainfall, rainfall collected, and percentage of rainfall collected, in inches, at Cochituate reservoir, during all but two years of the period 1852–'79.

The average rainfall was 49.59 inches, and the average percentage collected, 46.

Comparing the amount collected in any one year with the rainfall of that year, the greatest percentage was 78, and the least 25.

Comparing the amount collected in any one year with the mean annual rainfall, the greatest percentage was 94, and the least 30.

F.—In his report on the *Water-Power of Maine* (page 53), Mr. Walter Wells assumes 40 per cent. of the 42 inches annual rainfall of the state as passing off in the streams. He describes the state as, in general, moderately hilly, with a shallow soil, underlaid by hard and impervious rock. The northern slope of the state is comparatively uniform in elevation, and contains extensive swamps; the southern slope has a broken surface and a pretty uniform descent toward the sea. About one-fifth the surface of the state is more or less mountainous, and two-thirds is covered with forest.

G.—In a report made March 6, 1879, to the Newark aqueduct board, by Messrs. J. J. R. Croes and George W. Howell, on the subject of additional water-supply, the average annual yield of the Passaic, with a drainage area of 900 square miles, was estimated at 26.75 inches on that area, with a rainfall of 42.55 inches. The ratio of yield is 62.9 per cent. The rainfall on this basin varied, according to long continuous records, from 42.55 inches on the western boundary, to 46.40 and 53.80 inches, respectively, at two points near the eastern boundary. If we call the average for the basin 45 inches, then the ratio of assumed yield as above is 59.4 per cent. Regarding the surface drained, it is stated that—

> Topographically, the water-shed above Paterson consists of a great central basin of about 200 square miles area, with a general elevation of 120 to 180 feet above tide-water, and surrounded on three sides by a broken and rocky hill country, extending generally for about 12 miles from the basin.

In the same report (page 37), the average yield of the Concord river is given as 18.62 inches, on a drainage area of 352 square miles. I find the annual rainfall on the basin to be 42.47 inches, from which it appears that 43.84 per cent. of this is carried off by the stream.

Again, in this report (page 37), the average annual yield of the Merrimack is stated to be 29.85 inches on a drainage area of 4,136 square miles. From the Smithsonian records I estimate the mean annual rainfall to be 46 inches above Lowell. The mean discharge of the Merrimack is, therefore, 64.9 per cent. of the rainfall.

H.—The report on a *Survey of the Waters of the Upper Hudson and Raquette Rivers*, made by Farrand N. Benedict, in 1874, assumes (page 22) that the annual rainfall on the plateau is 64.53 inches, and the drainage 45.42 inches, or 70.4 per cent. Mr. Benedict also remarks that William H. Talcott, civil engineer, in his report of 1839 upon the supply of water for the Genesee canal, concluded from experiments made in connection with a reservoir on Madison brook that "the drainage of Madison Brook valley during the whole year is 0.518 of the rainfall".

I.—Humphreys and Abbot's report on the Mississippi river contains approximate determinations of the ratios between rainfall and drainage for that river and its chief tributaries. The ratios as given vary from 15 to 90 per cent., and will be found in detail in the summary.

J.—Captain Allen, in his calculations for a reservoir system at the headwaters of the Mississippi, assumed for the sources of that river a mean annual rainfall of 25 inches, and for the available quantity actually finding its way into the streams, 0.7 of a foot, or 33.6 per cent. of the rainfall. (See Appendix S 8, page 1199, *Report Chief of Engineers*, 1879.)

K.—In the fall of 1880, Mr. Joseph P. Frizell, United States assistant engineer, in examinations carried on in connection with the Mississippi reservoir system, made a reconnaissance of Rock river (Wisconsin and Illinois) for suitable reservoir sites. In his report concerning Horicon reservoir, situated some 50 miles northwest of Milwaukee, and having a drainage area of 491 square miles, he assumes a rainfall—that of Milwaukee—of 35.33 inches, and that 40 per cent. of this finds its way into the reservoir. (See *Report Chief of Engineers*, 1881, page 1809.)

L.—On page 2400, *Report Chief of Engineers*, 1881, is a report by Mr. C. D. Ward, United States assistant engineer, on a water-supply for the proposed enlargement of the Wabash and Erie, and Miami and Erie canals. In estimating concerning the reservoir supply for those canals, Mr. Ward assumes an annual drainage of 10 inches, from a rainfall, at Bellefontaine, of 40.49 inches, or a percentage of 24.7. He states that—

Most of the gathering ground being rather flat, the rain running off slowly, giving time for a large amount of evaporation before reaching the streams, I have assumed 10 inches as the annual drainage.

M.—Humphreys and Abbot give the drainage area of the Missouri river as 518,000 square miles, the annual downfall of rain as 25,200,000,000,000 cubic feet, and the percentage drained off as 15 (=3,780,000,000,000 cubic feet). I was informed by Major Charles R. Suter, corps of engineers, U. S. Army, that for the year 1879 the total discharge of the Missouri was 2,335,143,946,400 cubic feet, and that it was not, probably, materially different in 1880, although at the time of his letter the calculations had not been made for that year. If we assume the mean annual rainfall at the same rate as assumed by Humphreys and Abbot, but for the more recently determined drainage area of, in round numbers, 528,000 square miles, the above discharge represents a percentage of only 9.1 of the average rainfall. Whether the year 1879 was an unusually dry one throughout the Missouri basin, I am unable to say; the following records of the signal service, at several scattered points, show how the year compared in rainfall in those localities with the average of years:

Rainfall in 1879 *at points in the Missouri basin, compared with the average rainfall at those points.*

[From Signal Service records.]

Locality.	Years of record.	Rainfall, 1879.	Rainfall, average.	Ratio of 1879 to average.
		Inches.	*Inches.*	
Saint Louis, Missouri	1871–'80	25.70	36.99	0.69
Leavenworth, Kansas	1872–'80	41.55	39.30	1.06
Omaha, Nebraska	1873–'80	30.31	33.13	0.91
North Platte, Nebraska	1875–'80	20.06	18.13	1.12
Yankton, Dakota	1874–'80	22.83	27.34	0.83
Denver, Colorado	1872–'80	10.86	14.64	0.74

N.—Clear creek is a mountain tributary of the South Platte river, in Colorado. It issues from the foot-hills of the Rocky mountains at Golden, above which point its drainage area is 436 square miles. As the result of a large number of measurements, extending at intervals through a period of over twenty years, and made by Captain E. L. Berthoud, of Golden, it appears that the annual drainage past that point is about 7.75 inches on the water-shed. Captain Berthoud estimates the average rainfall at 20.62 inches, of which 37.6 per cent. is, therefore, carried off by the stream.

A summary is herewith presented of the facts hitherto given concerning drainage:

Table showing observed and assumed ratios of drainage to rainfall in various parts of the United States.

Stream or locality.	Drainage area.	MEAN ANNUAL RAINFALL.					Mean annual drainage.	Ratio of drainage to rainfall.	Remarks.
		Spring.	Summer.	Autumn.	Winter.	Year.			
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		
A.—Connecticut river, at Hartford.	*a* 10,234	10.30	11.90	11.30	9.20	42.70	26.800	0.628	Drainage determined by measurements of discharge at Hartford for eight years. Country drained hilly and mountainous, rocky and wooded.
B.—Sudbury river, Massachusetts.	78	12.20	12.60	11.70	9.60	46.10	21.927	0.4756	Drainage determined by careful measurements of discharge for six years. Country drained one-sixth to one-eighth wooded, balance farming land.
C.—West branch of Croton river.	20.37	12.70	15.50	12.00	9.80	50.00	31.458	0.6292	Drainage determined by measurements of discharge for forty-nine and a half months. Country drained broken and hilly, with steep rocky slopes, timbered, and little cultivated.
Croton river	335–339	12.70	14.35	13.08	9.66	49.79	25.130	0.505	Drainage determined by measurements of discharge for six years; less accurate, however, than in case of West branch. Drainage area includes that of West branch, but proportion of flat and cultivated land is much greater.
D.—Croton river...........	335–339	11.90	13.43	12.25	9.06	46.64	26.352	0.565	Drainage determined by measurements of discharge for thirteen years.
E.—Cochituate reservoir...	....	13.48	12.60	11.90	11.61	49.59	22.810	0.46	Based on observations for twenty-six years.
F.—Rivers of Maine	....	9.00	10.00	13.00	10.00	42.00	16.800	0.40	Assumed ratio of drainage in *Water-Power of Maine.* Surface of State moderately hilly, mountainous over about one-fifth, contains many lakes and swamps, is underlaid by impervious rock, and two-thirds covered with forest.
G.—Passaic river	900	10.93	11.93	11.42	8.27	42.55	26.750	0.629	Assumed ratio of drainage in estimating for water-supply. Rainfall assumed as given, though it varies on the drainage area from 42.55 to 46.40, and even 53.80 inches. Basin hilly and rocky.
Concord river..........	352	11.17	11.36	10.64	9.30	42.47	18.620	0.4384	Based on drainage as given by Croes and Howell.
Merrimack river.......	4,136	11.50	12.50	12.00	10.00	46.00	29.850	0.649	Do.
H.—New York plateau; upper waters of Hudson and Raquette rivers.	....	....	....	....	....	64.53	45.420	0.704	Ratio of drainage assumed by F. N. Benedict.
Madison brook, New York.	....	....	....	....	....	39.26 to 40.05	20.34 to 20.75	0.518	Conclusion as to ratio of drainage drawn by William H. Talcott, civil engineer, from experiments by John B. Jervis.
I.—Results for Mississippi river and tributaries, as given by Humphreys and Abbot: (*b*)									
Ohio river..............	214,000	10.80	12.00	9.30	9.30	....	10.057	0.24	Great variety of surface, from mountainous to rolling and flat, and from forest to open prairie.
Missouri river	518,000	7.10	6.50	4.40	2.70	....	3.141	0.15	Country mountainous and timbered at headwaters, but east of the Rocky mountains a rolling prairie without timber.
Upper Mississippi river	169,000	9.90	12.60	8.30	4.70	....	8.405	0.24	Heavy timber and many lakes.
Small tributaries.......	32,400	11.60	12.90	10.00	13.00	....	43.044	0.90	
Arkansas and White rivers.	189,000	6.80	11.60	7.20	4.00	....	4.555	0.15	Country mountainous at headwaters of Arkansas, thence eastward rolling prairie, till in Arkansas a more varied surface is encountered again, including some mountains and a large proportion of timber.
Red river	97,000	10.30	12.60	8.70	8.30	....	7.992	0.20	Large proportion of open prairie; lower basin timbered.
Yazoo river............	13,850	11.10	10.20	9.00	15.80	....	41.952	0.90	
Saint Francis river	10,500	11.10	10.60	8.50	10.70	....	40.584	0.90	Basin heavily timbered; upper part hilly and broken; lower sunken and flat.
Entire Mississippi, exclusive of Red river.	1,147,000	....	....	....	....	....	7.318	0.25	
J.—Headwaters of Mississippi.	....	....	....	....	....	25.00	8.400	0.336	Ratio assumed by Captain Charles J. Allen, corps of engineers, in calculations for reservoir system.
K.—Horicon lake, Wisconsin.	491	9.72	11.27	8.59	5.75	35.33	14.130	0.40	Ratio assumed by Joseph P. Frizell, in calculations for reservoir.
L.—Proposed enlargement of Wabash and Erie, and Miami and Erie canals.	....	10.01	14.25	8.13	8.10	40.49	10.000	0.247	Ratio assumed by C. D. Ward, in calculations for reservoir supply. Country flat.
M.—Missouri river	*c* 528,000	....	....	....	....	....	*d* 1.904	....	Drainage for 1879 = 0.091× estimated mean annual rainfall.
N.—Clear creek, Colorado..	436	....	....	....	....	20.62	7.750	0.376	Based on measurements by Captain E. L. Berthoud.

NOTE.—In some of the reports cited the rainfall is not given by seasons. In several such cases I have estimated the amounts from other rainfall records, and the figures must not, therefore, be depended on as strictly accurate.

a The drainage area taken in this article for the Connecticut river at Hartford is as given by Mr. Herschel, and is 80 square miles greater than my own measurement. The disagreement is too slight, however, to make any essential difference in the results obtained.

b In the case of the streams considered by Humphreys and Abbot I have stated the rainfall by seasons as given in their report. In estimating the yearly downfall, however, they adopted figures slightly different from the aggregates of the seasons as here given, and based upon the amounts shown by three different rain charts—the Army, Blodget's, and Delta Survey.

c Drainage area, in round numbers, by more recent measurement than that of Humphreys and Abbot.

d Year 1879 only.

The ratios of drainage which I have assumed in different sections range as follows:

Ratios of drainage to rainfall assumed in this work.

Section.	Mean annual rainfall on water-sheds considered. (a)	Assumed average annual drainage from water-sheds.	Assumed ratios of drainage to rainfall.
	Inches.	*Inches.*	
Region tributary to Long Island sound	40 -52	17½-27½	0.40-0.63
Hudson River basin	38 -40½	18 -24	0.45-0.60
Region tributary to lake Ontario	......	....	....
Eastern Gulf slope	49 -54	15½-24½	0.30-0.50
Ohio River basin (portion lying in Ohio, Pennsylvania, and the northern part of West Virginia)	......	....	....
Eastern Iowa slope	25½-42½	6½-12	0.25-0.30
Eastern Missouri slope	38½-39½	13½-14	0.35
Missouri River basin (portion draining to the main river below Yankton)	13 -41	2 -13½	0.10-0.35
Arkansas River basin (portion estimated upon is limited to southeastern Kansas and a part of the White River basin)	36½-39½	7½-13½	0.20-0.35
Red River basin (estimates confined to upper basin of Ouachita river)	50	12½	0.25

a The rainfalls here given are not necessarily the limits for the section considered, but rather refer to the data actually employed in estimates.

I shall now explain the second assumption made, viz, that of a certain proportional distribution of the drainage through the year. However uniform the volume of a stream may appear to the eye, it in reality hardly remains the same two days in succession, or, indeed, two hours in succession, but is subject to constant fluctuations, even though they be at times slight. The periods of high and low water are also of variable occurrence, and in a series of years may range through nearly every season. If, now, we take the flow of a stream by days for an entire year, and arrange it according to the days of least discharge, representing the average discharge of each day by a suitable ordinate, an approximation to some sort of a curve will result, which will illustrate the distribution of the flow through that year. If we are able to employ as the basis in constructing the curve the results of gaugings extending through a series of years, the characteristic of the stream as regards flow will be shown with great accuracy. My own experience in constructing such curves has been that, although from the records of a single year only a broken line may result, having no well-defined curvature, yet from the gaugings of a series of years a quite regular and beautiful curve will be obtained. This method of showing graphically the distribution of flow of any stream was, I think, first practically described and carried out by Mr. Clemens Herschel; (*a*) he arranged the results of gaugings by calendar months of least and greatest flow, but for my purposes I have preferred to arrange them by days where they were accessible in that form.

The forms which the curves, determined in this manner, may take, are infinite in variety, being due to all those diverse conditions, and their combinations, of climate and surface features, which affect the flow of streams. There are certain general principles, however, which may be observed regarding them. It is obvious that if the rate of discharge of a stream were to remain fixed and invariable throughout the year, its flow would be represented by a straight line parallel to the axis of abscissas. Any causes which act to throw it out of that condition of uniform flow will tend to produce a curve, and the greater the extremes between low and high water, the more will the curve depart from the position corresponding to an invariable volume.

We may construct the curves on three different bases:

1. With respect to the absolute rate of discharge in cubic feet per second per square mile of drainage area. The curves thus formed will show the striking contrast that exists between the streams of the Atlantic slope and those of the western prairie regions, as regards the yield per square mile. If the average high-water discharge of the Missouri river were at the same rate per square mile as that of the Connecticut, it would amount to over 6,000,000 cubic feet per second; and, similarly, the low-water discharge would be about 285,000 cubic feet per second.

2. Relatively to low water (average low water where that is known), taken as a basis of reference. In this manner the fluctuations of the streams will be brought out more prominently, and it will be noticed that the Arkansas, for instance, for the single year given, although its curve under the first case is flat, and shows only small variations in discharge per square mile, was really subject to a very great relative fluctuation of volume between low and high water.

3. We may construct the curves with reference to mean flow for a series of years, considering that as unity, or a basis of reference.

Such numerical data as I have been able to find, and upon which the curves shown are based, are given below. There are a few cases in which the gaugings have been carried through a series of years; I have also included some examples in which they were made for several months or a year only, and these may have some interest, though they are of much less practical value than the former.

a *Remarks on the Gauging of Streams*, made June 18, 1878, at the tenth annual convention of the American Society of Civil Engineers, by Clemens Herschel, civil engineer, member of the society. Mr. Herschel states that he received the first suggestion of the method from Mr. Joseph P. Davis, city engineer of Boston.

Table showing distribution of flow of streams through the year, in cubic feet per second per square mile of drainage area.

(a) ARRANGED ACCORDING TO DAYS OF LEAST DISCHARGE.

Stream.	Approximate drainage area.	Average (a) lowest day of the year, cubic feet per second per square mile.	30th.	60th.	90th.	120th.	150th.	180th.	210th.	240th.	270th.	300th.	330th.	360th.	Highest day.	Average flow for period here used, cubic feet per second per square mile.	Average flow for series of years, (b) cubic feet per second per square mile.
	Sq. miles.																
Connecticut, at Hartford (c)	10, 234	0. 540	0. 620	0. 690	0. 760	0. 870	1. 030	1. 250	1. 540	1. 970	2. 480	3. 250	4. 730	7. 720	11. 420	2. 021	d1. 973
Arkansas (e)	160, 000	0. 015	0. 022	0. 032	0. 056	0. 206	0. 269	0. 319	0. 364	0. 400	0. 425	0. 450	0. 469	0. 508	0. 538	0. 275	(?)0. 335
Mississippi, at Columbus (f)	930, 540	0. 140	0. 180	0. 260	0. 350	0. 460	0. 510	0. 570	0. 640	0. 730	0. 930	1. 140	1. 260	1. 490	1. 510	0. 662	0. 520
Mississippi, at Vicksburg and Natchez (g)	1, 154, 607	0. 200	0. 250	0. 340	0. 450	0. 620	0. 720	0. 760	0. 910	0. 990	1. 040	1. 060	1. 070	......	1. 080	0. 701	0. 539
Mississippi, at Carrollton (h)	1, 160, 000 to 1, 170, 000	0. 172	0. 219	0. 236	0. 253	0. 288	0. 412	0. 494	0. 618	0. 678	0. 735	0. 800	0. 910	0. 969	0. 989	0. 507	0. 539

a The average lowest day is employed where the records used cover more than one year.
b In some cases the results of this column are based upon longer records than were accessible for the detailed data necessary in making out the main portion of the table.
c Deduced from gaugings for the seven years 1872-'78.
d Eight years.
e Deduced from gaugings at Napoleon as given by Humphreys and Abbot; December 10, 1857, to December 6, 1858.
f From gaugings as given by Humphreys and Abbot; December 1, 1857, to November 30, 1858.
g From gaugings as given by Humphreys and Abbot; January 3 to December 15, 1858.
h From gaugings as given by Humphreys and Abbot; February 15, 1851, to February 18, 1852. Drainage area is exclusive of that of Red river.

(b) ARRANGED ACCORDING TO CALENDAR MONTHS OF LEAST DISCHARGE.

Stream.	Approximate drainage. area.	Average (a) lowest month of the year, cubic feet per second per square mile.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	Average flow for period here used, cubic feet per second per square mile.	Average flow for series of years, (b) cubic feet per second per square mile.
	Sq. miles.														
Sudbury (c)	78	0. 170	0. 250	0. 430	0. 600	0. 790	1. 120	1. 420	1. 850	2. 100	2. 630	3. 980	5. 890	1. 754	1. 615
West branch of Croton (d)	20	0. 390	0. 540	0. 760	0. 870	1. 120	1. 500	2. 380	2. 540	3. 140	4. 390	4. 680	6. 110	2. 317	2. 317
Croton (e)	339	0. 494	0. 839	0. 989	1. 069	1. 263	1. 607	2. 031	2. 269	2. 446	2. 667	3. 179	3. 5[illegible]2	1. 866	1. 940
Concord (e)	352	0. 344	0. 406	0. 450	0. 539	0. 671	0. 848	1. 104	1. 342	1. 695	2. 102	2. 649	4. 291	1. 371	1. 371
Passaic (f)	900	0. 530	0. 751	0. 971	1. 104	1. 325	1. 589	1. 898	2. 208	2. 561	3. 002	3. 532	4. 150	1. 969	1. 969
Merrimack (e)	4, 136	0. 680	0. 777	0. 936	1. 113	1. 342	1. 589	1. 872	2. 199	2. 675	3. 294	4. 088	5. 792	2. 197	2. 197
Missouri (g)	528, 000	0. 057	0. 065	0. 068	0. 074	0. 078	0. 090	0. 098	0. 146	0. 160	0. 204	0. 303	0. 341	0. 140	0. 231
Connecticut, at Hartford (h)	10, 234	0. 649	0. 690	0. 760	0. 885	1. 152	1. 397	1. 656	2. 102	2. 435	2. 830	4. 427	5. 270	1. 973	1. 973

a The average lowest month is employed where the records used cover more than one year.
b In some cases the results of this column are based upon longer records than were accessible for the detailed data necessary in making out the main portion of the table.
c Deduced from careful gaugings for the five years 1875–'79.
d From gaugings for the three following years: May, 1867, to April, 1868; January to December, 1870; January to December, 1871.
e Deduced from monthly average flow for a series of years, as given by Croes and Howell in report to Newark aqueduct board, 1879.
f Deduced from monthly average flow for a series of years, as estimated by Croes and Howell in report to Newark aqueduct board, 1879.
g From gaugings for the year 1879.
h From gaugings for the eight years, 1871–'78.

Flow as given in preceding table, arranged relatively to lowest day or month.

(a) BY DAYS OF LEAST DISCHARGE.

Stream.	Average lowest day (assumed as unity).	30th.	60th.	90th.	120th.	150th.	180th.	210th.	240th.	270th.	300th.	330th.	360th.	Highest day.
Connecticut	1.00	1.15	1.28	1.41	1.61	1.91	2.31	2.85	3.65	4.59	6.02	8.76	14.30	21.15
Arkansas (a)	1.00	1.49	2.16	3.82	14.03	18.28	21.68	24.74	27.21	28.91	30.61	31.88	34.56	36.56
Mississippi, at Columbus (a)	1.00	1.29	1.86	2.50	3.29	3.64	4.07	4.57	5.21	6.64	8.14	9.00	10.64	10.79
Mississippi, at Vicksburg and Natchez (a)	1.00	1.25	1.70	2.25	3.10	3.60	3.80	4.55	4.99	5.20	5.30	5.35	....	5.40
Mississippi, at Carrollton (a)	1.00	1.27	1.37	1.47	1.67	2.39	2.87	3.59	3.94	4.27	4.65	5.29	5.63	5.75

(b) BY MONTHS OF LEAST DISCHARGE.

Stream.	Average lowest month (assumed as unity).	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.
Sudbury	1.00	1.47	2.53	3.53	4.65	6.59	8.35	10.88	12.35	15.47	24.59	34.65
West branch of Croton	1.00	1.38	1.95	2.23	2.87	3.85	6.10	6.51	8.05	11.26	12.00	15.67
Croton	1.00	1.70	2.00	2.16	2.56	3.25	4.11	4.59	4.95	5.40	6.44	7.15
Concord	1.00	1.18	1.31	1.57	1.95	2.47	3.21	3.90	4.93	6.11	7.70	12.47
Passaic	1.00	1.42	1.83	2.08	2.50	3.00	3.58	4.17	4.83	5.66	6.66	7.83
Merrimack	1.00	1.14	1.38	1.64	1.97	2.34	2.75	3.22	3.93	4.84	6.01	8.52
Missouri (a)	1.00	1.14	1.19	1.30	1.37	1.58	1.72	2.56	2.81	3.58	5.32	5.98
Connecticut	1.00	1.06	1.17	1.36	1.77	2.15	2.55	3.24	3.75	4.36	6.82	8.12

a Results based upon observations for a single year, as previously noticed.

Flow as given in table on preceding page, arranged relatively to average flow for a series of years.

(a) BY DAYS OF LEAST DISCHARGE.

Stream.	Average flow (assumed as unity).	Average lowest day.	30th.	60th.	90th.	120th.	150th.	180th.	210th.	240th.	270th.	300th.	330th.	360th.	Highest day.
Connecticut	1.00	0.27	0.31	0.35	0.39	0.44	0.52	0.63	0.78	1.00	1.26	1.65	2.40	3.91	5.79
Arkansas (a)	1.00	0.04	0.07	0.10	0.17	0.62	0.80	0.95	1.09	1.19	1.27	1.34	1.40	1.52	1.60
Mississippi, at Columbus (a)	1.00	0.27	0.35	0.50	0.67	0.88	0.98	1.10	1.23	1.40	1.79	2.19	2.42	2.87	2.90
Mississippi, at Vicksburg and Natchez (a)	1.00	0.37	0.46	0.63	0.83	1.15	1.33	1.41	1.69	1.84	1.93	1.97	1.99	....	2.00
Mississippi, at Carrollton (a)	1.00	0.32	0.41	0.44	0.47	0.53	0.76	0.92	1.15	1.26	1.36	1.48	1.69	1.80	1.83

(b) BY MONTHS OF LEAST DISCHARGE.

Stream.	Average flow (assumed as unity).	Average lowest month.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.
Sudbury	1.00	0.11	0.16	0.27	0.37	0.49	0.69	0.88	1.15	1.30	1.63	2.46	3.65
West branch of Croton	1.00	0.17	0.23	0.33	0.38	0.48	0.65	1.03	1.10	1.36	1.90	2.02	2.64
Croton	1.00	0.25	0.43	0.51	0.55	0.65	0.83	1.05	1.17	1.26	1.37	1.64	1.82
Concord	1.00	0.25	0.30	0.33	0.39	0.42	0.62	0.81	0.98	1.24	1.53	1.93	3.13
Passaic	1.00	0.27	0.38	0.49	0.56	0.67	0.81	0.96	1.12	1.30	1.52	1.79	2.11
Merrimack	1.00	0.31	0.35	0.43	0.51	0.61	0.72	0.81	1.00	1.22	1.50	1.86	2.64
Missouri (a)	1.00	0.25	0.28	0.29	0.32	0.34	0.39	0.42	0.63	0.69	0.88	1.31	1.48
Connecticut	1.00	0.33	0.35	0.39	0.45	0.58	0.71	0.84	1.07	1.23	1.43	2.24	2.67

a Results based upon observations for a single year, as previously noticed.

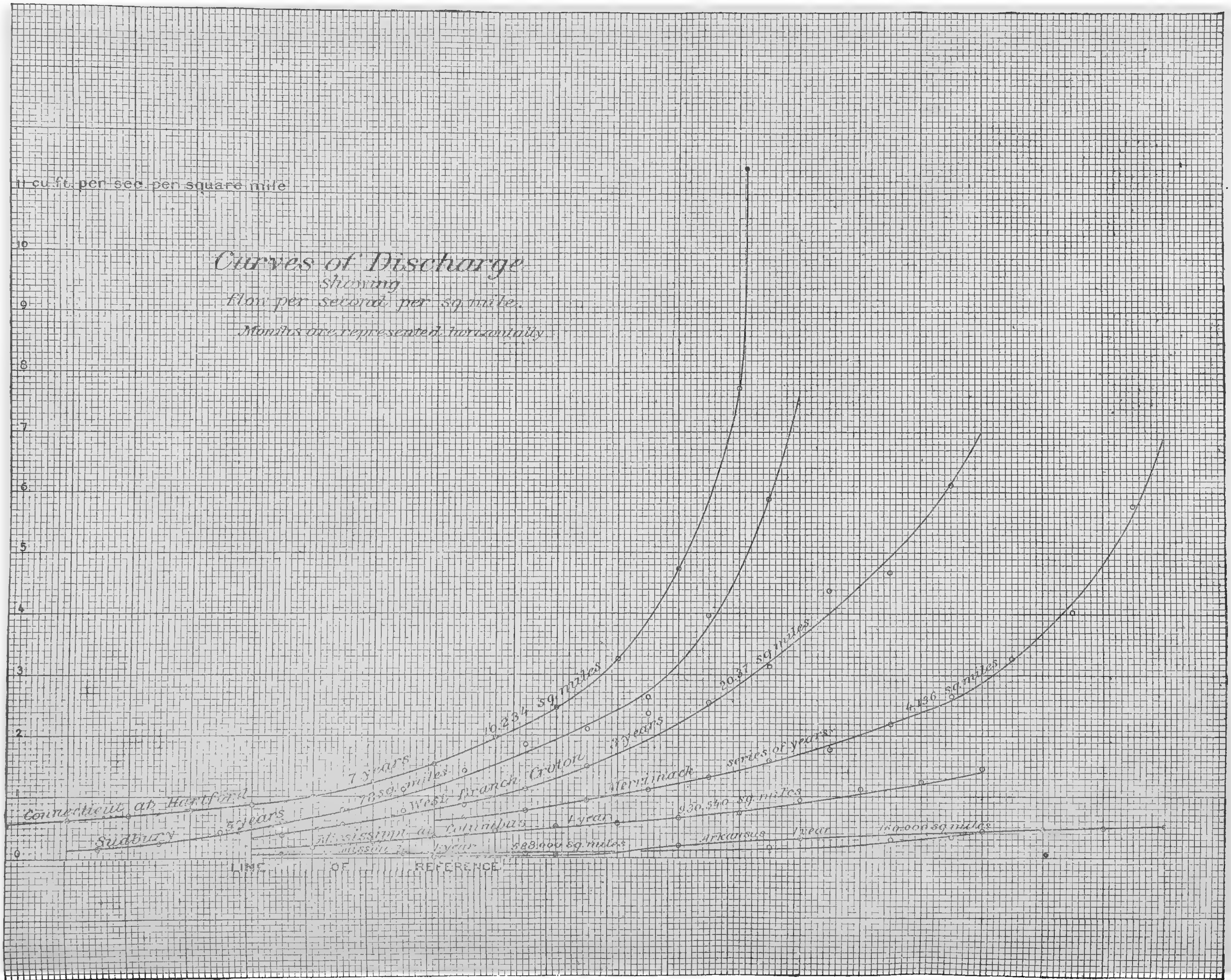

FIG. 1.—Curves of discharge.

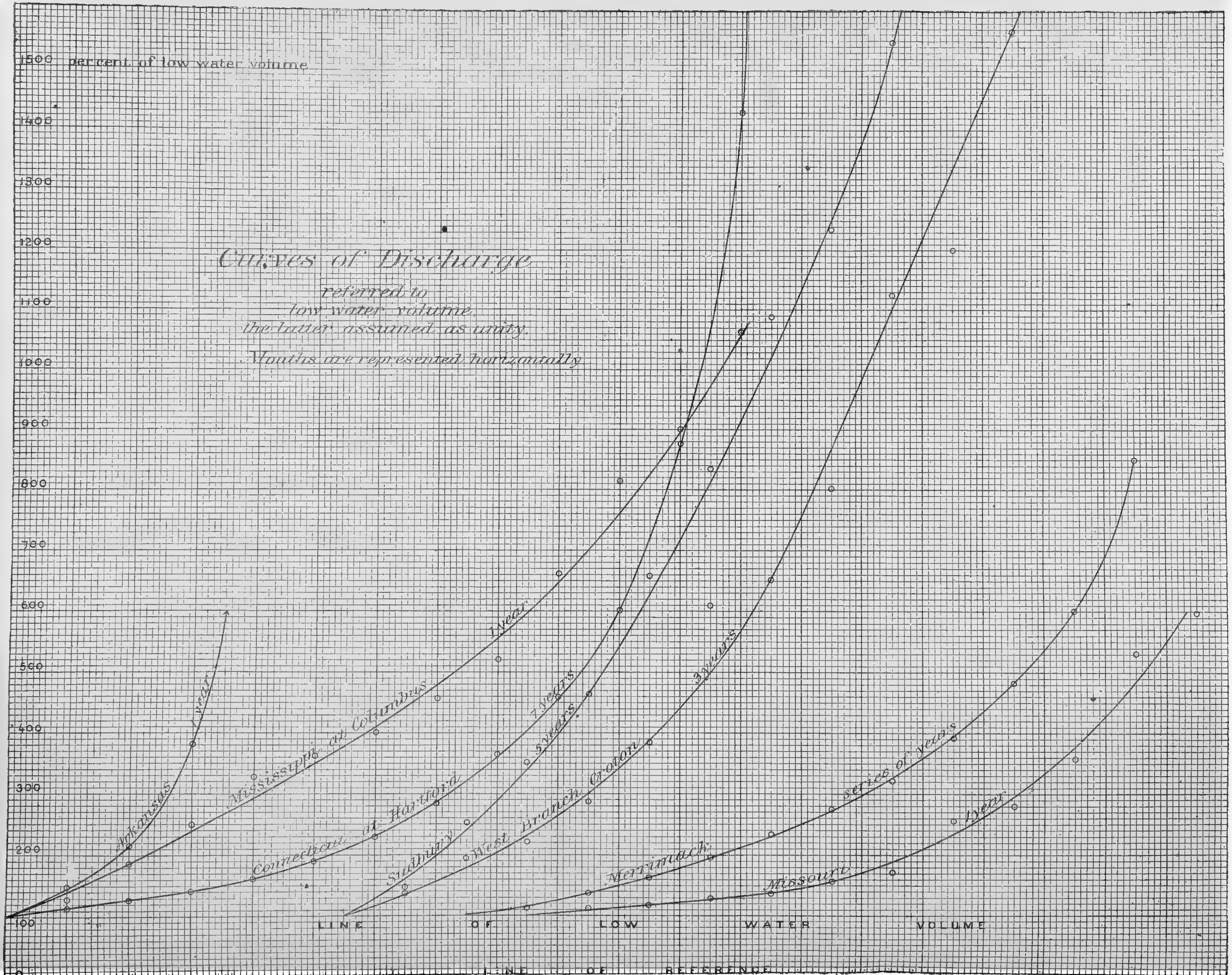

FIG. 2.—Curves of discharge.

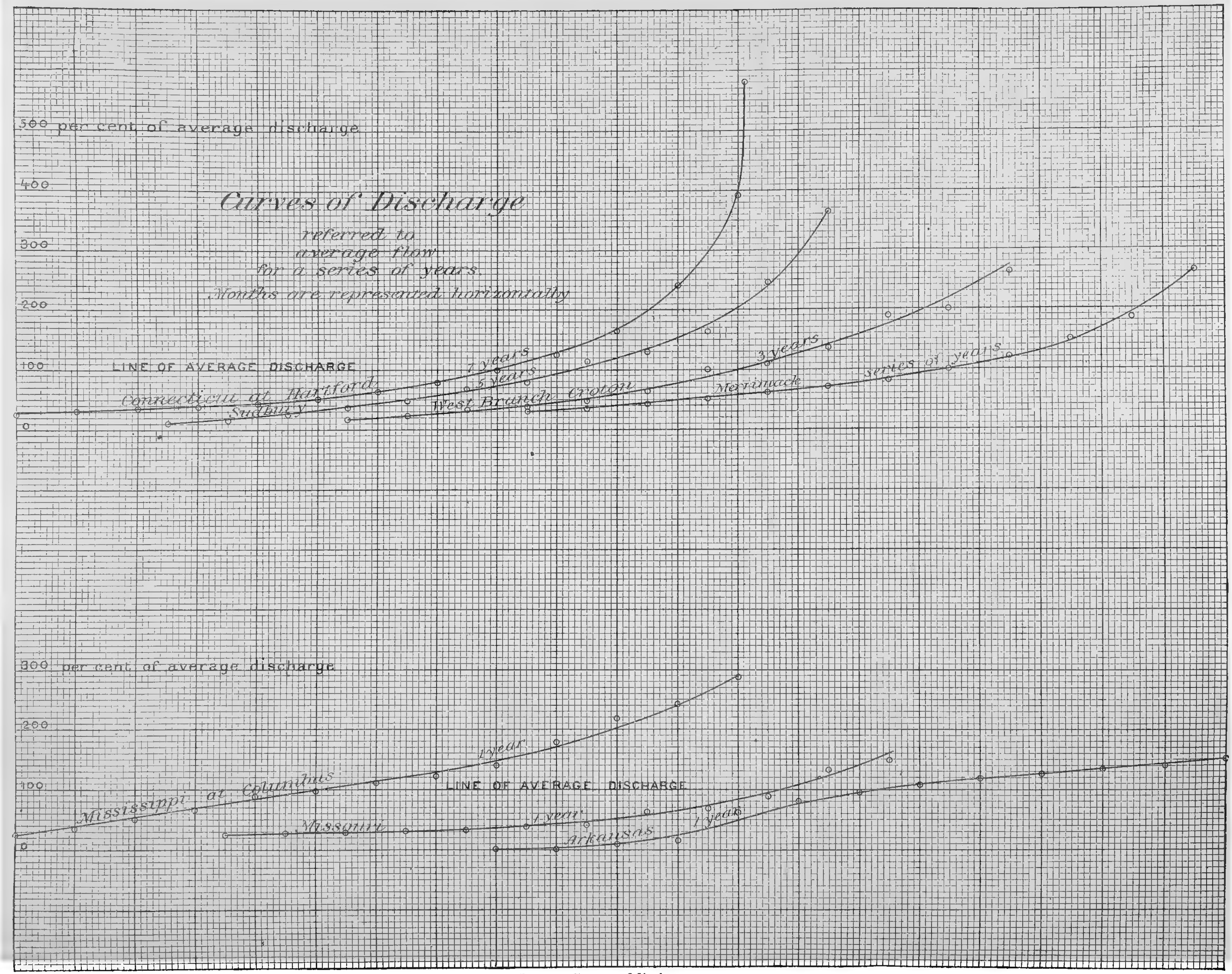

FIG. 3.—Curves of discharge.

In fixing upon the rate of discharge for low water of a dry year I have assumed a certain absolute figure per square mile of drainage area for each stream, in the selection of which I have been guided by the results of gaugings made either upon the stream considered, or upon some neighboring one. The ratio which exists between low water of a dry year and that of an average year, as determined by measurements, can be given in only a few cases, as follows:

Ratio between low water of dry and of average years.

Stream.	Approximate drainage area.	Low water of dry year, cubic feet per second per square mile.	Low water of average year, cubic feet per second per square mile.	Ratio dry to average year.	Remarks.
	Sq. miles.				
Connecticut, at Hartford	10, 234	0. 509	0. 540	0. 94	Obtained from records previously referred to, by comparing the gaugings of the lowest days in each of the years from 1872 to 1878. The extreme range for those gaugings was from about 0.51 to 0.59 cubic foot per second per square mile.
Do	....	0. 598	0. 649	0. 92	Obtained from records for eight years, 1871–'78, by comparing the total discharge of the calendar months of least flow in each year. The extreme range for those totals was from about 0.60 to 0.715 cubic foot per second per square mile.
Sudbury	78	0. 092	0. 170	0. 54	Obtained by comparing the total discharge of the calendar months of least flow in each of the five years 1875–'79. The extreme range for those totals was from 0.092 to 0.284 cubic foot per second per square mile.
West branch of Croton	20	0. 084	0. 390	0. 22	Obtained by comparing the total discharge of the calendar months of least flow in each of the three years: May, 1867, to April, 1868; January to December, 1870, and January to December, 1871. The extreme range for those totals was from 0.084 to 0.736 cubic foot per second per square mile.
Croton	339	0. 177	0. 494	0. 36	Obtained by comparing the monthly dry-season flow with the monthly average flow for a series of years, as given by Croes and Howell, in report to Newark aqueduct board.
Concord	352	0. 221	0. 344	0. 64	Do.
Passaic (estimated)	900	0. 177	0. 530	0. 33	Do.
Merrimack	4, 136	0. 601	0. 680	0. 88	Do.
Illinois	29, 000	0. 055	0. 060	0. 92	Obtained by comparing extreme low-water flow and ordinary low-water flow, as given by Major G. J. Lydecker, corps of engineers, U. S. Army.

THE REGION TRIBUTARY TO LONG ISLAND SOUND.

TOPOGRAPHY OF THE SURFACE AND GENERAL FEATURES OF THE STREAMS.

The section of country which will here be considered extends from the Thames basin, on the east, westerly to that of the Bronx, including both, and comprises an area of about 15,500 square miles. It stretches from 250 to 275 miles in a north-and-south direction, and has an extreme width of about 100 miles; it is confined chiefly to Connecticut, Massachusetts, Vermont, and New Hampshire, but also embraces small portions of Rhode Island, New York, and Canada.

The surface is nearly everywhere hilly, and is even, to a considerable extent, mountainous. The Norfolk hills in northwestern Connecticut, probably the most elevated land in that state, rise to elevations of over 1,400 feet. Graylock, the highest point of Saddle mountain, in Berkshire county, Massachusetts, situated slightly beyond the western border of the region I am describing, reaches a height of nearly 3,600 feet above tide-water. Mount Holyoke, in the same state, is nearly 1,000 feet high. To the northward, the peaks of the Green mountains, in Vermont, reach elevations of 2,500 to 4,300 feet above sea-level; and those of the White mountains, in New Hampshire, 4,000 to 6,000 feet and over.(a) The White mountains are stated to cover an area of 1,270 square miles, and in appearance are quite in contrast with the Green mountains, being more rugged and less fertile. The mountain ranges of western New England have a generally north-and-south direction, and to the southward, where the country is less elevated, the same trend is preserved by parallel lines of hills. The rocks which compose the mountains and otherwise crop out over the general surface of the country, are of the older formations, and are mainly comprised in granite, gneiss, mica-slate, mica-schist, and syenite. They are intersected by numerous dikes of trap, and an extensive ridge of that material runs in a northerly direction from New Haven, on the sound, across Connecticut and half-way across Massachusetts. As an exception to the general class of rocks mentioned above, is to be noted a belt of red sandstone, which also starts from the vicinity of New Haven, strikes northeasterly to the Connecticut River valley, and follows its course up to the northern boundary of Massachusetts.

Stretching down from the western slope of the Green mountains over the western portion of the region we are studying, and embracing the Taconic range in Massachusetts and a part of Connecticut, are outcropping limestone strata, which furnish valuable supplies of marble. Granite and gneiss of fine quality for architectural purposes are quarried at various points, and along the Housatonic valley are extensive deposits of hematite iron ore, which are worked, however, only to a small extent.

Along the course of the Connecticut, and in a much less degree along most of the other streams, are alluvial deposits, but the great and abounding surface material is almost everywhere drift. It covers the entire region from east to west and from north to south, its southern boundary running lengthwise of Long Island. Its constituents are here, as elsewhere, sand, clay, gravel, and bowlders. In the *Report on the Geology of Vermont* various bowlders are described weighing from 500 up to 3,500 tons each. Rocks and stones lie irregularly scattered over and beneath the surface, and many hill-sides are so thickly covered with them as to present a very barren and forbidding appearance. The drift covers even the higher portions of the Green mountains. As to the thickness which the deposit attains in some parts of New England, Dr. Hitchcock, in his *Report on the Geology of Massachusetts*, remarks that in that state it has been found at Palmer to the depth of 70 to 80 feet without reaching rock, and that in Plymouth and Barnstable, hills of it exist 300 feet in height. In other parts of the state he estimates the maximum thickness at 100 feet.

The soil varies greatly in fertility; the alluvial meadows along the Connecticut, Farmington, Lower Deerfield, and other rivers, are very productive, while the more elevated country is often stony and poor; and yet the conditions are, in other cases, not infrequently reversed, the hill-tops being rich farming land and the neighboring valleys of the smaller streams almost worthless. The country may be said, as a whole, to be well wooded; the

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a Mount Washington has an altitude of 6,293 feet.

timber is largely of a young growth, and in southern New England is mostly found upon the hills, which, owing in many cases to their height and steepness, or the poorness of their soil, are reserved for woodland, the lower ground being devoted to agriculture. The leading varieties of timber are hemlock, fir, spruce, pine, oak, beech, sugar-maple, hickory, elm, butternut, basswood, birch, cedar, ash, and poplar. What forests remain are in the north, and it is there that the principal cutting of timber now goes on. The destruction there is just as thorough and apparently indiscriminate as it is stated to be in other portions of the United States, and the section along the upper course of the Connecticut river appears more bare than much that it drains toward its mouth.

Lakes constitute a noticeable and important surface feature. They are well distributed, being found quite generally throughout the region I am describing. In the Vermont geological report already referred to, Mr. Albert D. Hager gives a list of 67 lakes and ponds in that state varying from half a mile to 8 miles in length, and from half a mile to 2½ miles in width. In Appendix B of the report for 1873 of the Massachusetts State Board of Health a list prepared by Mr. H. F. Walling is given of all the lakes, ponds, and reservoirs in that state containing more than 10 acres. The total number of these is 1,206, with an aggregate area of about 93,000 acres, or, say, 145 square miles. Their distribution is as follows, by counties and according to size:

Number and size of lakes, ponds, and reservoirs in Massachusetts.

Size.	Number.	Size.	Number.
10 to 100 acres	976	700 to 800 acres	4
100 to 200 acres	135	800 to 900 acres	1
200 to 300 acres	42	1,000 to 2,000 acres	5
300 to 400 acres	26	Over 2,000 acres (2,007 and 2,220)	2
400 to 500 acres	6		
500 to 600 acres	5	Total number	1,206
600 to 700 acres	4		

Distribution.

County.	Area of lakes, ponds, and reservoirs.	County.	Area of lakes, ponds, and reservoirs.
	Acres.		*Acres.*
Berkshire	6,226	Bristol	7,961
Franklin	2,184	Plymouth	17,623
Hampshire	2,282	Barnstable	9,721
Hampden	4,148	Dukes	90
Worcester	25,007	Nantucket	33
Middlesex	8,743		
Essex	4,570	Total area	92,938
Norfolk	4,350		

As to the origin of the Vermont lakes, Mr. Hager says:

The position and extent of lakes, as well as mountains, are dependent, in a great measure, upon the geological character of the country in which they lie. Their origin is the result of three distinct causes, and hence lakes and ponds may properly be divided into three classes: First, those where the beds were formed at very remote periods, when the upheaval of the rock took place, and left deeply indented fissures; secondly, those that occupy deep, eroded valleys; and thirdly, those of more recent date, and not dependent upon a rock formation for their base or sides, but upon a deposit of clay or some other substance impervious to water, reposing upon a gravelly or hard-pan base. A limited examination has been made of the lakes and ponds, to determine the nature of their origin; and our conclusions are that much the larger proportion of lakes and ponds belong to the second class, and occupy eroded basins. The third class of ponds in Vermont is not of the antiquity of the first two classes, and such ponds are not dependent upon rock formations for their base and sides. They date back to the period of the drift for their origin, being found in drift formations, and doubtless rest upon a basin-shaped cavity lined with clay or some substance impervious to water. They are usually fed by deep-seated springs, and rarely have large visible outlets or inlets.

The following table will convey a general idea of the temperature and rainfall, during the different seasons of the year, over the region tributary to Long Island sound. It is necessarily faulty in one important respect, in that it is almost entirely confined to low altitudes, there being very few stations of more than 1,000 feet elevation where long-continued climatic observations have been made. It is a well-known fact that rainfall increases with altitude, a striking example of which is seen in the record for Mt. Washington; and it would be of much assistance in gaining a correct knowledge of the proportional discharge of such a stream as the Connecticut, if accurate information were available concerning the downfall on the more elevated portions of its basin.

Table of temperature and rainfall at points in southern and western New England.

[From Smithsonian records.]

Locality.	Elevation above sea.	TEMPERATURE. Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.	RAINFALL. Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
	Feet.		°	°	°	°	°		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
New Haven, Connecticut	45	86	46.76	69.63	51.28	28.32	49.00	27	11.24	12.11	11.19	10.90	45.44
Hartford, Connecticut	60	16	47.89	69.75	51.70	29.89	49.81	7	11.08	9.98	11.92	10.81	43.79
Amherst, Massachusetts	267	17	44.17	67.58	47.99	24.15	45.97	39	10.62	12.45	11.16	9.73	43.96
Hanover, New Hampshire	530	20	40.87	65.15	44.76	19.17	42.49	19	9.91	11.09	10.58	9.08	40.66
Stratford, New Hampshire	1,000	13	37.71	62.95	42.68	15.50	39.71	16	9.91	11.18	11.15	8.48	40.72
Randolph, Vermont	700	6	39.60	66.55	45.28	19.02	42.61	8	8.40	10.66	11.29	8.16	38.51
Mount Washington, New Hampshire.	6,293	......	....	....	....	....	....	4	13.96	23.66	19.80	9.70	67.12

NOTE.—In Blodget's *Climatology* it is stated that "the quantity of snow is always large in the New England states, the elevated and northern districts having an average of perhaps 2 feet constantly remaining on the ground in winter". The following are records of snowfall at particular points:

	Inches.
Dover, New Hampshire, average of ten years	68.6
Burlington, Vermont, average of ten years	85.0
Worcester, Massachusetts, average of twelve years	55.0
Amherst, Massachusetts, average of seven years	54.0
Hartford, Connecticut, average of twenty-four years	43.0

According to J. H. Huntington, in an article on "Climatology", in the *Geology of New Hampshire*, observations on snowfall at Lunenburg, Vermont, have shown the average annual amount there to be 83.1 inches, ranging in twenty-five years from 41 to 167.5 inches.

It is hardly necessary to say that the water-power of the section that has been described is of great magnitude and value, but it may be of interest to notice the causes which contribute to those conditions. In the first place, the streams have a rapid fall and large volume. There are very few which can be called sluggish, and even the Connecticut, which approaches most nearly to that character (the Thames is hardly more than an estuary), is interrupted at intervals by heavy rapids and falls. The elevated character of the country is so sustained toward the south that not only are there many minor tributaries there which have large descent, but the main streams, also, have considerable fall within a short distance from tide-water, and at points, therefore, where their accumulated volume is the greatest. Oxoboxo brook, a small stream entering the Thames about midway between Norwich and the mouth, falls not less than 350 feet in 6 miles, and, being supplied by a reservoir, furnishes power to a dozen or more factories in that distance. Within a radius of about 15 miles from Norwich there is a fall of over 140 feet in the Shetucket river, and over 100 feet in the Quinebaug, utilized in part on the former by cotton, woolen, and other factories. On the Housatonic a fall of 22 feet is utilized at Birmingham, at the head of tide-water, and only 11 miles by navigable river from the sound.

The descent of the New England streams is not very uniform. Among the more mountainous sections in the north there are numerous abrupt pitches, and these are also interspersed more or less over nearly all the streams, even to southern Connecticut. But in the more open and moderately hilly districts the drift gravels have to a large extent filled up the beds of the streams, over which the latter run in rapids and rifts, interrupted only now and then by falls over projecting ledges. In northwestern Connecticut the Housatonic falls over 100 feet in probably less than half a mile, and descends more than half this distance in a single plunge; and again, farther south on the same river, at Bull's bridge and New Milford, are other falls of less magnitude. At Norwich, in the southeast, the falls of the Yantic are of great beauty.

The rocks which give rise to the falls are of the harder varieties—granite, gneiss, and mica-schist—and by their unyielding character not only insure the permanency of the falls, but afford secure foundations for dams and other hydraulic works. It is not at all uncommon to meet with dams in this region fifty years old, and I have come across some that have stood securely for certainly a hundred years. This same hardness of the rocks has also prevented the cutting of the deep and inaccessible cañons which distinguish many of the streams in the softer formations of the Rocky mountains.

The volume of the streams is also large in proportion to the extent of country drained. The prevailing steep slopes, the rather shallow soil in many localities, the imperviousness of the underlying rock, and the temperate climate, combine to favor a large proportional discharge. The average annual rainfall for the entire district is probably not far from 45 inches.

As to the uniformity of flow of the streams, some idea may perhaps be gained from what has been said in a previous article on the modes of estimate employed. The term "uniformity" can be used in this connection only in a relative sense, for there is no stream of much size which is strictly uniform in discharge. There are occasional streams so controlled by lakes or reservoirs as to be equally free from considerable freshets and from periods of very

low flow, and which have, therefore, an approximation to real uniformity; but most are subject to large fluctuations between high and low water. For practical purposes, however, we may speak of a stream as uniform which is, on the whole, well sustained in the dry season, and which is not visited by very sudden or great changes in volume. The New England rivers have a tolerably good character in these respects. The hard underlying rock, not commonly far below the level of the stream beds, and forming the valley sides, sheds water freely toward them; while the gravels, sands, and clays of the drift favor the reception of rain from the surface and its delivery through springs. The wooded nature of the country also favors the easy percolation of water below the surface of the ground, shades from undue evaporation, and conserves the winter snows; and perhaps above all other causes should be mentioned the numerous lakes and swamps.

Dr. Hitchcock, in his geological report published in 1841, roughly estimated that the state of Massachusetts contained 125 square miles of peat swamps alone; the area of swampy land not containing peat would greatly increase this figure, but I have no data as to its real extent. Percival, in a *Report on the Geology of the State of Connecticut*, made in 1841, mentioned that "swamps abounding more or less in peat are found in every town in the state". The influence both of lakes and of swamps is very marked on streams, and perhaps in favor of the latter of the two. Their great advantage lies in their storing and holding back the rains which would otherwise be too quickly carried off by the water-courses. While lakes accomplish this result in a very important degree, swamps seem even more effective, owing to the obstacles which they oppose to any but a gradual drainage, in their shallow depth and their usual rank growth of grasses and brush.

The benefit accruing to a stream which has these natural regulators is illustrated in the case of the Quaboag river, a tributary of the Chicopee, in Massachusetts. Surrounding its upper course are extensive marshes, which give it a very steady flow, the rise on the West Warren dams not exceeding 18 inches, in an ordinary spring freshet, on an overflow of about 110 feet, and this from a drainage area of 142 square miles.

The value of even the ordinary storage provided along the course of a stream by the mill-dams was well shown in the great flood which swept down the course of the Westfield river, in Massachusetts, December 10, 1878. In a report upon methods for future protection of the town of Westfield, which suffered severely at that time, Mr. Hiram F. Mills, civil engineer, remarked as follows:

> From data supplied by your sub-committee on surveys, I conclude that the greatest quantity of water passing Salmon Falls dam was 53,000 cubic feet per second, from a drainage area of 350 square miles; and at the same time there were entering the area between Salmon Falls and Westfield dam about 1,000 cubic feet per second, from an area of 14 square miles. A part of this 54,000 cubic feet per second was expended in filling the great reservoir, containing probably as much as 100,000,000 cubic feet of water, between these two dams, and a part in flowing over the Westfield dam. Every reservoir that the water fills in its course serves as a regulator, which prolongs the time of flowing past any dam down the stream, but tends to decrease the amount passing at any moment. This is illustrated by the greatest quantity per second which is shown by the data of your survey to have passed the Salmon Falls dam and the Agawam (*a*) dam; the former quantity being 53,000 cubic feet per second, and the latter, although increased by the drainage from 40 per cent. more area, was but 46,000 cubic feet per second. This decrease in quantity, at the time of highest water, at the lower dam was due to a part of the water from above being used in filling the enormous reservoirs between the two dams, which drained off gradually after the flood had passed the upper dam.

While, as has been said, the effect of lakes and swamps is so helpful in lessening freshets and maintaining a good volume during droughts, their usefulness in these respects is much increased by artificially enlarging their storage and controlling them; in other words, by making true storage reservoirs of them, and instead of permitting their contents to run off at all seasons, as in the natural state, saving them in winter and spring for use during the dry months of summer and autumn. And in this improvement of the New England streams by storage reservoirs seems to me to lie their most noteworthy and interesting feature.

It is very difficult to obtain reliable data as to either the area or cost of these improvements, except in occasional instances. Many of them were undertaken years ago, and neither then nor more recently does much attention seem to have been paid to an accurate record of facts concerning them. It is certainly true, however, that in many cases they have been been built at a merely nominal expense. Natural ponds of several hundred, or even a thousand acres and over, have been raised a number of feet by means of a short and inexpensive embankment, probably not costing more than a few thousand dollars at the most. It is in this manner, by raising the level of some natural pond or lake, that most of the storage reservoirs seem to have been created. They are usually so located among hills that it is possible to raise their surfaces considerably without their flowage spreading out unreasonably far; and these hills often close in at the outlets, so that only a short dam is needed to connect them and control the pond. This sort of topography is, indeed, common through all that portion of New England which I have visited. The courses of the streams are flanked by hills, which successively approach and recede from them, forming what are termed "intervales" of meadow or gently-sloping land.

The class of reservoirs which I have just described is largely of natural formation. A second class is almost entirely artificial, and is formed by throwing an embankment across the course of some small stream in its upper waters, at the foot of an intervale of swampy land. An unusual number of such opportunities have existed and been availed of in eastern Connecticut and the adjoining portion of Rhode Island. Such reservoirs are easily and cheaply constructed, the land for flowage having but little agricultural value, in consequence of

a Agawam is about 8 miles by river below Westfield, and the latter 6 to 7 miles below Salmon Falls.

which the land damages are small. It has been stated to me by a manufacturer who had investigated the subject, that on the upper course of the Moosup river, in western Rhode Island, 3,000 acres of reservoir room could be added to the stream by flowing almost worthless swamp land, at an expense of only $4,000 total for flowage and improvements, and others agree that the opportunities there for large storage are very favorable. The reservoirs of this class have the advantage over those first mentioned, that in proportion to their cubic contents their storage is generally more accessible, because of their being comparatively shallow; though it is true, on the other hand, that they suffer greater loss by evaporation, and receive less water from deep-seated springs. Many of the natural ponds are so deep that a large share of the water they contain cannot be drawn out at all. This makes no difference, to be sure, in the available amount of water for power, provided the topography is such that the proportion of annual rainfall received can be stored above the level which is accessible, but that cannot always be done.

A third class of reservoirs, and the least numerous of all, is constructed by building a high embankment or dam across a narrow gorge. The area available for flowage in this case being small, an adequate storage has to be provided for by increase of depth, and hence by high dams. The reservoirs thus built are probably the most expensive in construction, and certainly the most dangerous to maintain, of any that have been described. There should be little difficulty in properly building and maintaining an embankment 5 or 10 feet high, but it is quite another thing to obtain equal security with an embankment 30 or 40 feet high.

The construction and maintenance of storage reservoirs are often carried out by individual mill-owners on a stream, but perhaps as commonly by associations of the various parties to be benefited. The expenses of construction and repairs are assessed upon the members, either in proportion to the fall owned, or upon some other basis. The system seems generally to work well, but cases are not uncommon in which members in some manner evade their assessments, or in which parties refuse to contribute at all, and so enjoy the benefits of the improvements but escape the burdens.

The change which may be brought about in the flow of a stream by properly developing the storage capacity of its basin is strikingly seen in the instance of the Pachaug river, a tributary of the Quinebaug, in southeastern Connecticut, draining about 60 square miles. Twenty years ago the Ashland cotton-mill, located near the mouth, contained seventy looms, but could only run a portion of the year, and had much trouble from lack of water. The stream was afterward finely reservoired, however, and now the Ashland mill carries five hundred looms, and has not been stopped more than a day and a half by low water since 1865.

Notwithstanding that the New England streams are fairly well sustained in the dry season, there are certain conditions which act unfavorably upon them. The rainfall in summer is perhaps slightly greater than during the other seasons, yet it is not sufficiently so to counteract the heavy evaporation of that period, and so, for the machinery employed, there is generally a deficiency of water in the streams for two or three months in the year, and an excess for eight or nine months. The draining of swamps and the cutting of timber also act to materially injure the uniformity of flow. As was remarked to me by a Massachusetts mill-owner, the farmers and manufacturers are directly opposed as regards the draining of swamp-land. The former wish to reclaim as much surface as possible for cultivation, and it is said that a Massachusetts agricultural society encourages such improvements by premiums. On the other hand, manufacturers appreciate the value of swamps in maintaining the low-water flow of their mill-streams, and desire them to remain.

Some of the effects on the streams of the wholesale destruction of timber are perfectly well known. It is certain enough that they are subject to more sudden fluctuations and are less sustained in droughts than before the country was cleared. These results are matters of common observation among men whose memories reach back over fifty, forty, or even twenty years; it is a universal complaint in New England that the mill-streams are less reliable, excepting, of course, where artificially reservoired, than they were that length of time ago, and this is due both to the clearing of land and to the drainage of swamps. The principal freshets in the region under discussion are caused by the melting of snow in the spring, and while the effect of forests is, by shading the ground, to prevent this going on too rapidly, so, on the other hand, their destruction lays the surface open to the direct action of the sun, and gives good opportunity for a quick wasting away of the snow. The record of the heights of freshets in the Connecticut river for thirty-five years back shows that in this stream, whether we have regard to the highest freshets of the year or to the highest occurring during the first five months, which latter may be supposed to have a connection with the melting of snow, there has been a considerable increase in the average heights reached.

Table showing average heights of freshets in the Connecticut river. (*a*)

HIGHEST OF THE YEAR.		HIGHEST OF FIRST FIVE MONTHS.	
Period.	Average height.	Period.	Average height.
	Feet.		*Feet.*
1844 to 1849	18.54	1845 to 1848	18.56
1850 to 1859	20.52	1850 to 1859	19.36
1860 to 1869	21.18	1860 to 1869	21.18
1870 to 1879	21.71	1870 to 1879	21.06

a Compiled from record given in report on survey of the river below Hartford; see *Report Chief of Engineers*, 1880.

While it seems evident that from some cause, which may reasonably be assumed to be the clearing up of the country, the tendency is to a gradual increase in the average height of freshets, it is not so certain that the *extremes* of fluctuation are any greater now, as maintained by some, than formerly; indeed, concerning the Connecticut, the reverse appears true. General Theodore G. Ellis, in an elaborate report upon this river, (*a*) speaks thus of its freshets:

The Connecticut river is subject to freshets of considerable height, which occur principally in the spring, when the volume is swollen by the melting snow, although occasional floods have occurred in every month of the year except July and September. The highest freshets generally take place in the spring. There was one remarkable exception, however, in August, 1856, when the water at Hartford rose to a height of 23 feet 4 inches above low-water mark. This was caused by unusually heavy rains which occurred at that time. The freshet of May, 1854, is the highest known below Holyoke. This was 29 feet and 10 inches above the low-water mark of the Hartford gauge. The freshet of April, 1862, was the highest known on Holyoke dam, and was probably the highest in the river above that point. Previous to these two freshets the flood of 1801 was the highest on record, and formed the basis of most of the points of reference along the river previous to 1854.

The lowest water known was that of August, 1858.

The fact is, I think, that remarkable freshets, as well as periods of extremely low water, are to such an extent the result of accidental combinations of favoring conditions—such as sudden rains upon a frozen surface, rapid thawing of a heavy body of snow; or, on the other hand, an uncommonly prolonged drought, or a drought following a season of small rainfall—that it is not fair to assume them as necessarily caused by the clearing away of the forests.

In speaking of the effect of melting snow upon such a stream as the Connecticut, for instance, an important circumstance to be noted is its position in a north-and-south line. In this direction it extends some 275 miles, covering quite a range of climate. The average temperature of March at Hartford is not gained at Stratford, New Hampshire, till April, nor that of April at Hartford till May in Stratford. The chances are, therefore, that the melting of snow will extend rather gradually up the valley and its effect upon the stream be prolonged, whereas if the river lay in an east-and-west direction, having but little range in climate, a much more sudden and perhaps disastrous freshet rise might be anticipated.

Low water is the principal disadvantage encountered in this section in the use of water-power. Freshets do not often endanger properly-constructed works, and the rapid slopes of the streams carry off the floods so quickly that an absolute stoppage of operations is seldom necessary, and serious trouble from backwater lasts but a few days at the most. Quite thick ice forms in the winter-time on the rivers, and during the spring break-up gorges occur at some points, but, in general, the action of floating ice is not destructive, and largely because of the extensive improvements in the way of dams and reservoirs, which always ameliorate the natural condition of a stream. In the ponds formed by the dams the ice is usually held back until so rotten that when broken it can do little harm, and in going over successive dams it is soon shattered into fine fragments.

A somewhat troublesome feature during the winter season is the presence in the streams of what is called in New England "anchor-ice"; farther west, "slush-ice", and which abroad is variously known as "ground-ice", "bottom-ice", and "loppered-ice". We are most familiar with ice as formed upon the surface of water, but anchor-ice collects on the beds of streams, from which, in rising, it often tears up small stones or masses of gravel. It is crystalline in structure, and in the water resembles a kind of fungus or vegetable growth; at times a stream will be seen full of little masses of anchor-ice floating along near or at the surface. Its consistency is often very slight, so that if an attempt is made to grasp it in the hand it readily melts and disappears. It forms on the head-gates of canals, on the racks at the entrances to flumes, and if allowed to pass into a wheel-pit is liable to stop the wheel. Although the latter experience is an extreme one and not commonly met, a large amount of labor in the aggregate has to be performed on the streams in the northern part of the United States in keeping clear the racks and head-gates.

Anchor-ice is confined mainly to swift-running streams having gravelly or stony beds, and all mill-owners agree that it ceases to hinder them as soon as the rivers become frozen over on the surface. Streams fed largely from ponds and lakes near at hand, the waters of which are warmer than those running in the usual channels, are free from this form of ice. In my visits to the various streams I made many inquiries of manufacturers concerning anchor ice, but though all were familiar with its occurrence, few had observed with much closeness the circumstances attending its formation. At Windsor Locks, on the Connecticut river, much trouble is encountered from anchor-ice, owing to its collecting upon the head-gates of the canal, and the consequent clogging, but it is said to be noticed only when there is a very cold wind blowing. For 18 miles above the dam the river is sluggish and free from rapids, but is then interrupted by the heavy falls at Holyoke. Near Olean, New York, on the Allegheny river, a prominent mill-owner, long familiar with the stream, stated to me that anchor-ice, or, as he called it, "slush-ice", was of common occurrence there; that when previously running upon the surface of the river, the coming up of a south wind would cause it to settle and to begin clogging the water-wheels, and that it was generally considered on that part of the river that the settling of the ice betokened a coming thaw.

a Appendix B 14, *Report Chief of Engineers for* 1878.

In an article by Colonel Jackson, on the "Congelation of the Neva at St. Petersburg", (*a*) he states having observed ground-ice in that river where the latter had a depth of 35 feet and was covered with a coating of surface-ice 3 feet thick, the ground-ice appeared not only upon the bottom of the river, but also beneath the surface coating, and was made up of little flakes or scales.

Various hypotheses have been advanced to account for the formation of anchor-ice. Dr. Farquharson claimed it to be the result of radiation of heat from the river bed, and to be formed on the same principle as dew. The Rev. Mr. Eisdale, of England, stoutly maintained that it was produced by little spiculæ of hoar-frost falling from the atmosphere into the water. But the principles which seem to me to best explain the phenomena of anchor-ice are those advanced by M. Arago, and thus briefly given in the English Cyclopædia:

1. The reversion, by the motion of the current, of the hydrostatic order, by which the water at the surface cooled by the colder air, and which at all points of the temperature of water under 39° F. would, in still water, continue to float on the surface, is mixed with the warmer water below; and thus the whole body of water to the bottom is cooled alike by a mechanical action of the stream.

2. The aptitude to the formation of crystals of ice on the stones and asperities of the bottom in the water wholly cooled to 32°, similar to the readiness with which crystals form on pointed and rough bodies in a saturated saline solution.

3. The existence of a less impediment to the formation of crystals in the slower motion of the water at the bottom than in the more rapid one near or at the surface.

That the whole body of water is thoroughly chilled, and in a condition to crystallize readily upon any hard nucleus, may be shown, I am told, by lowering a pole into the stream, when it will speedily become coated with the anchor-ice. The masses of ice which cling by adhesion to the stones on the river bed grow in size, and at length attain sufficient buoyancy to loosen their fastenings and rise to the surface. It is often said by observers that this action is most marked soon after sunrise.

Less difficulty seems to be experienced from the source mentioned where the mill-ponds are large and deep, and water is brought directly from them to the wheels, or, at least, is passed through canals of good depth, than where the ponds are small and shallow, and water is carried a considerable distance in canals of slight depth, especially if their bottoms are stony. The most common mode of dealing with anchor-ice is to rake it away by hand from the racks, although occasionally the plan is tried of introducing a jet of steam into the flume to disperse it.

In connection with the streams it is interesting to notice the special kinds of manufacturing which have come to distinguish certain of them. Thus, on the tributaries of the Thames we find cotton- and woolen-mills; on the Connecticut and upper Housatonic, paper-mills; on Miller's river, various manufactures in wood; on the Naugatuck and at Birmingham, Connecticut, metal-working establishments; at the outlet of Pocatopaug lake, Connecticut, bell manufactories, and so on.

Great as has already become the use of water-power in the section draining toward Long Island sound, the opportunities for further development are still ample, and are being frequently availed of. In my own observation, the improvement of new privileges and the more extended use of old ones have gone on quite largely in the past two years (1880–'82), and these improvements have generally been of important powers, and are characterized by their substantial and expensive nature. New England certainly possesses some very valuable advantages for manufacturing in the abundance and desirable qualities of her water-power, in her nearness to tide-water, her established and well-equipped lines of communication with the coal districts and great centers of trade, such as New York and Boston, in her compact and numerous population, in her possession of a large and prosperous class of skilled laborers, in the bias and inclination which her people have acquired for manufacturing pursuits, and in the extent of her available capital. The last item must not be underrated. Very many of the manufacturing companies have a capital ranging from $1,000,000 upward. Some of the largest cotton-mills, when stocked with their elegant machinery, are said to have cost $1,000,000 or $2,000,000 each, and a large additional capital is evidently required for carrying on business of such magnitude. For cotton manufacturing, the location as regards obtaining raw material is less favorable than in the South: for the manufacture of paper, which has assumed great prominence rags and wood-pulp are easily obtained, and the abundance of pure water is an essential advantage.

One great obstacle to the improvement of many water-powers is the rather grasping and short-sighted policy pursued by adjoining land-owners or by the owners of the privileges themselves. These are often held for speculation at unreasonable prices. If the development of a water-privilege is considered by a company of capitalists, meadow-land, which must be bought for flowage, and which has, perhaps, produced a moderate crop of coarse grass, at once assumes a wonderful value in the eyes of its proprietors, and is sometimes hardly to be purchased at any price. Although this experience is probably exceptional, it has certainly prevented, in some instances, the establishment of important enterprises. It would seem to be much the better plan for the farmers to encourage, by all reasonable means, the introduction of manufactures. Farming is not regarded as a very profitable industry in New England, but its gains ought surely to be increased by the founding of villages which must be supplied with farm products. Not only this, but the development of manufacturing points tends to a substantial increase in the value of real estate, and for the sake of that advantage it is sometimes thought good policy to give away water-rights to desirable companies without charge.

a *Journal of the Royal Geographical Society*, Vol. V.

I.—THE THAMES RIVER AND TRIBUTARIES.

THE THAMES RIVER.

This stream drains the eastern part of Connecticut and small portions of Rhode Island and Massachusetts, the area of its basin being 1,450 square miles. The country thus included is almost everywhere hilly, is tolerably well wooded, though with a young growth, and contains many natural lakes and ponds which have been improved for reservoirs. Much of the land on the hills is stony and poor, with little value for anything but pasturage. The principal industry of this section is its manufacturing, which has assumed great importance, especially in the matter of cotton and woolen goods. The first successful water-mill for the manufacture of cotton goods in the United States was completed and put in operation by Messrs. Almy, Brown, and Samuel Slater, early in 1793, at Pawtucket, Rhode Island, (*a*) and the period which has since elapsed has witnessed a wonderful growth in this branch of enterprise, both in Rhode Island and in the adjoining portion of Connecticut, as well as in other parts of the eastern states.

The Thames river is formed at Norwich, New London county, Connecticut, by the union of the Shetucket and Yantic. It runs southerly and empties at New London, at the eastern extremity of Long Island sound. Its width generally ranges from a quarter to a half mile, except near the mouth, where it widens to a full mile and forms the magnificent harbor of New London. It is a tidal stream, the mean rise and fall of tide at New London being 2.5 feet, and at Norwich 3.1 feet. (*b*) The distance from the latter point to the mouth is about 15 miles, which is navigable for vessels of 12 feet draught; in 1880 the shallowest part of the channel had a depth of at least 10 feet at mean low water, and operations have since been carried on by the national government with the view of obtaining a depth of 14 feet at that stage.

The river is bordered on either side by high hills, and is a most beautiful stream. Below Norwich no tributaries are received except a few small streams; one of these, however, Oxoboxo brook, which is fed by a large reservoir, supplies power to a number of factories.

TRIBUTARIES OF THE THAMES BELOW THE JUNCTION OF THE SHETUCKET AND YANTIC RIVERS.

I shall speak only of those tributaries coming in from the west, small, as already stated, and including Alewife, Oxoboxo, Stony, and Trading Cove brooks.

The high hills which border the Thames are here thickly wooded, except toward the lower ground, with chestnut and oak. The surface is very rocky, displaying many granite and gneiss bowlders and outcropping ledges. The mills and dams on the Oxoboxo are in numerous instances built of those varieties of rock, quarried in the valley. The surrounding country has small agricultural value, and is but little cultivated; corn, potatoes, and grass are the principal productions.

Alewife brook is a little stream, half a dozen miles long, and draining about 10 square miles lying in the towns of Montville and Waterford. At the head is an artificial reservoir 1 mile long and reaching half the width, with a dam 20 feet high at the outlet; it can be pretty thoroughly drawn out, but does not appear to be so well sustained by springs as Oxoboxo reservoir to the northward. It is said that by means of a dam 40 feet high a reservoir can be constructed between the two Robertson privileges, 2 miles long and three-quarters of a mile wide. The site is favorable for a dam, and the entire expense for flowage and construction is estimated not to exceed $6,000. It is claimed that with this reservoir built the mills could run at full capacity throughout the year; as it is, the supply of water is sufficient only about six months in the year, say from January to July, after which the mills shut down. There are four privileges in use on the stream, covering a total of about 76 feet fall, and all utilized by paper-mills. The lowest and uppermost mills are owned by O. Woodruff, and the two intervening by J. Robertson's Sons. At the Robertson mills an aggregate of about 90 horse-power is in use.

Oxoboxo brook heads in a reservoir of the same name, whence it flows southeasterly across the town of Montville, draining 13 square miles. The reservoir contains about 160 acres, and is a natural lake raised, and having its flowage increased, by a granite dam at the outlet; it is quite deep, and a considerable portion of its contents can not be drawn out on that account. The Uncasville Manufacturing Company owns the reservoir, but so regulates the supply from it as to accommodate the other manufacturers.

The valley of the stream is narrow and hemmed in by steep slopes, thickly wooded on their upper portions, but having a thin covering of soil and rapidly shedding rainfall. This valley derives its importance solely from manufacturing, and has scarcely any population aside from that connected with the mills. The New London

a Bishop's *History of American Manufacturing.*

b As stated by Major J. W. Barlow, corps of engineers, U. S. Army.

Northern railroad crosses at the mouth, and Montville station, which is located there, is stated to rank third among the stations on this line as regards the amount of freighting. Goods were formerly shipped by water from the mouth of the stream, but that practice has been given up. All transportation from the mills to Montville station is by team, though it is practicable to construct a railroad up the valley, and the subject has been somewhat considered.

The brook runs over a gravelly bed, underlaid by rock, which frequently crops out. Its fall is rapid, amounting to over 350 feet in the 6 miles from the reservoir to the mouth. The mills succeed one another closely, each dam setting back the stream nearly or quite to the next one above. The ponds are, as a rule, small and of little account; the pond at the Uncasville mill is larger than the rest, however, and would of itself probably supply the mill for a day or two. The dams are short, and usually consist of an embankment on one or both sides of the stream, with a roll-way (*a*) of granite or wood; they appear to be tight, and two or three are very solidly constructed. Water is conveyed to the wheels variously by wooden flumes, iron tubes, and canals carried along the side hills; the canals are short, seldom exceeding a few hundred feet in length. The mills are of fair size and well built, frequently of stone. They have generally increased their capacity in recent years, and, in consequence, have been obliged to introduce steam for auxiliary power, relying more or less upon that for three months in the year.

The flow of the stream, of course, depends upon the manner in which it is regulated at the reservoir, but it was represented to me to be ordinarily about 30 cubic feet per second. It is said that the dry-season flow could be considerably increased by a reservoir which might be built, at reasonable expense, on Fox brook, which joins the Oxoboxo at Oakdale. The annual rainfall in this section is about 50 inches, and unless the area drained is larger than appears on the map which I have used, a greater average flow for the year than 20 to 25 cubic feet per second, continuous through 24 hours of the day, cannot be expected.

August 25, 1877, after a very heavy rain, of the nature of a "cloud-burst", during which 8.5 inches of rain were reported to have fallen in three hours, the upper mill-dam, below the reservoir, gave way, and carried out, in succession, nearly all the dams below, causing a damage estimated at $40,000.

The manufacturing on this stream is mainly of cotton and woolen goods and paper. Some details concerning the privileges are given below:

Water-privileges on Oxoboxo brook (in order from the mouth).

Firm.	Manufacture.	Fall.	Horse-power utilized.	Remarks.
		Feet.		
Johnson & Co.	Dye-woods and extracts	14	....	Privilege is nominally rated at 50 effective horse-power, which can be realized nine months in the year.
Uncasville Manufacturing Company.	Cotton goods	40	167	Dam has 60 feet of roll-way of solid granite masonry; remainder is granite facing filled in with gravel. Can realize about two-thirds capacity of wheels in dry times.
Pequot Mills	Cotton goods	16 36	42 136	Granite dam, 30 feet high. Privilege is in two successive falls; an iron penstock carries water to the upper mill, and a race thence to the lower mill.
R. G. Hooper & Co.	Unoccupied	12–16	....	
Do	Cloakings	25–26	55	
Palmer Brothers	Bed comfortables and cotton rope	13	25	
A. Hurlbut	Twine and cotton cordage	8	20	
C. M. Robertson	Paper	22	40	
Do	....do	40	60–65	
Do	Small grist-mill and shoddy-mill.	20	25–30	Privilege owned by C. M. Robertson.
Do	Unimproved	8–10	....	
Palmer Brothers	Bed comfortables	26	90	Masonry dam with gravel embankment. Race and flume 500–600 feet long. Can run full capacity nine months in the year, and 60 horse-power the remainder.
C. F. Schofield	Woolen goods	12	24	1-set mill.
B. F. Schofield	....do	11	20	1-set mill.
Do	Unimproved	20	....	
Do	Saw-mill	19	20	
Do	Unimproved	15–20	....	Between saw-mill and reservoir.

Stony and *Trading Cove brooks* are little streams lying to the north of Oxoboxo brook, and draining 8 and 12 square miles, respectively. The first has a grist- and saw-mill near the mouth, and a shingle- and grist-mill some distance above. The fall is rapid, and there are reported good opportunities for reservoirs, but there is now very little water running in the dry season.

Trading Cove brook has a small woolen-mill at the mouth, and one or two powers in use farther up. It is not thought to be as good a stream as Stony brook; its fall is slight, and in the summer of 1882 it ran nearly or quite dry.

a In New England the term "roll-way" is applied to that portion of the dam between the abutments, and over which the stream flows.

THE SHETUCKET RIVER.

The Willimantic and Natchaug rivers unite, immediately below Willimantic borough, to form the Shetucket, which then runs to the southeast and joins the Yantic at Norwich. It is 18¾ miles long, and lies mainly in the towns of Windham and Sprague and between those of Norwich and Lisbon. Norwich, at the mouth, is a wealthy and beautiful city, containing a population of 15,000, and is the center of important manufacturing interests. Three miles above the city the Quinebaug enters the main river from the east, and is, in fact, of more consequence than the Shetucket above their junction, containing a larger area in its basin, and being better supplied with reservoirs. Between this point and Willimantic, Little river and Merrick's brook are received from the east, and Beaver brook from the west, but they are all small streams.

The only elevations which I have been able to obtain for the Shetucket and its tributaries are those furnished by an old survey, instituted by citizens of Norwich in 1825, the record of which was kindly loaned me by Moses Pierce, esq., of that city. In view of the large developments of water-power which have since been made on those streams, and some of which, I am informed, have been based directly upon the data supplied by the survey, it is interesting to recall the words of its originators: "We, the subscribers, believing that the improvement of the unoccupied water-privileges on the Quinebaug and Shetucket rivers would be a great public benefit, and for the purpose of ascertaining the number, magnitude, location, and value of the privileges on said rivers, hereby agree to pay the sums affixed, etc. * * * Norwich, January 24th, 1825".

Mr. Pierce states that the survey has been found correct whenever there has been occasion to verify any portion, and it is fair to assume that the rest is equally reliable. It extended from tide-water up the Quinebaug river to Danielsonville, the entire length of the Shetucket, and about 3 miles above its head on the Willimantic and Natchaug. The total fall in the Shetucket river was found to be 144.25 feet, equivalent to an average of about 7.7 feet per mile, distributed as below:

Table showing fall in the Shetucket river.

[From survey of 1825.]

Section of river.	Distance.	Fall.	
	Rods.	*Ft.*	*in.*
Junction Willimantic and Natchaug to Bingham's bridge	452	12	8
Thence to Island bridge	560	7	10
Thence to lower end of Dyer's ditch	302	7	8
Thence to foot of falls, below Manning's bridge	364	8	3
From foot of falls (200 rods below Manning's bridge) to mouth of Waldo's brook at Wood's bridge	574	11	4
Thence to tide-water	3,748	96	6
Total from junction of Willimantic and Natchaug to tide-water	6,000	144	3

NOTE.—From the junction of the Willimantic and Natchaug nearly half-way to Norwich, or to Baltic slackwater, the fall, amounting to about 54 feet, is unimproved. For the remainder of the distance it is practically all developed.

The points on this river at which it is used for power are, in order from the mouth, Norwich, or perhaps more properly Greeneville, a suburb of the city, Taftville, Occum, and Baltic; between Baltic and Willimantic there are two unimproved privileges, which will be described later.

The drainage area of the Shetucket is 1,245 square miles, of which 512 are above its junction with the Quinebaug, while 725 belong to the latter stream. Excepting those of the Quinebaug basin, the principal lakes and storage reservoirs of the Shetucket drain into it through the Willimantic and Natchaug rivers, and hence benefit the whole length of the river below. Their location and approximate areas are as follows:

Lakes and reservoirs in the Willimantic and Natchaug basins.

Name.	Location.	Approximate area. (a)	Outlet.
		Acres.	
Staffordville reservoir	Northeast part of town of Stafford	200	Furnace brook.
Square pond (reservoir)	Ellington and Stafford	*175	Reaches West branch of Willimantic river.
Orcuttville reservoir	Town of Stafford		Middle river.
Wangumbaug lake (reservoir)	Town of Coventry	*450	Outlet runs to Willimantic river.
Bolton reservoir	Northern part of town of Bolton	500	Hop river.
Columbia reservoir	Town of Columbia	282	Drains to Hop river.
Black lake	Western part of town of Woodstock	*80	Drains to Natchaug river.
Crystal lake (reservoir)	Eastford and Woodstock	200	Still river to Natchaug.
Eastford reservoir	Town of Eastford	200	Drains to Natchaug river.

a Not very accurate probably, but the best estimates I could obtain; where marked by a star (*) areas were measured on map of state of Connecticut.

The Shetucket river rises rapidly after rains, usually coming up for about twelve hours after a storm has ceased, and then gradually falls away; even an ordinary rain has an important effect upon its volume, and when the supply is low will sometimes give the mills plenty of water for several weeks. There is very little low ground along the stream, and the banks are not overflowed. Backwater causes but little hindrance and never any stoppage to the mills. At Baltic the working head is sometimes reduced 3 or 4 feet, but the trouble is only experienced during a very few days in the year. A depth of 4 feet of water flowing over the dam (roll-way 515 feet long) is considered quite a large freshet rise. At Taftville the ordinary spring-freshet rise below the dam is 5 or 6 feet, and the hinderance from backwater is stated as even less than at Baltic, amounting to only a foot or two net reduction of head, and that for but one or two days.

Neither is there any trouble worth mentioning from ice. Whatever floating ice comes down from the upper river runs out on to extensive flats near Scotland station and melts there; little ice, therefore, except that formed below Scotland, goes over the Baltic dam, and at Taftville the depth of water running over the crest of the dam is so small, not amounting to more than 3 or 4 feet in common freshets, that the ice does not escape from the pond until so thoroughly rotted as to be harmless.

Although, as I have stated, the ordinary freshets in the Shetucket are not serious, yet, in at least two instances, it has been visited by destructive floods. March 26, 1876, the river rose to such a height as to run 10 feet deep over the Taftville dam, and 12 or 14 feet deep over that at Greeneville. This was on Sunday. Through the preceding week heavy rains had filled all the reservoirs, and during Saturday night drenching showers carried the streams out of their beds. The storm was general and disastrous in Connecticut, Rhode Island, and Massachusetts; it was stated that in the vicinity of Providence 4.06 inches of rain fell during Saturday and Saturday night, making 7.66 inches in six days. The losses by this freshet were great throughout the section in which it occurred, and were estimated to amount to several hundred thousand dollars in eastern Connecticut. Dams were carried away, mills were injured, warehouses submerged, and railroad embankments washed out. The larger part of the damage was along the course of the Shetucket river. At Baltic a portion of the dam and part of the mill were carried away; the bulkhead of the Occum dam was washed out, and the mill suffered injury; and at Taftville the embankment forming a part of the dam would probably have been overcome, and the splendid mill destroyed, had not the former been protected by a hastily-built breastwork of rock and bales of cotton-waste.

Again, almost exactly a year later, on the morning of March 27, 1877, the storage reservoir at Staffordville gave way, and caused heavy losses in the town of Stafford, and especially at Stafford Springs.

Improved privileges.—Ascending the river, the first power is that at Greeneville, immediately above Norwich. The river in this vicinity is skirted by high hills, rising steadily from the water, and but slightly timbered; it is about 300 feet wide between banks, with a bed composed of gravel and small bowlders.

The old Greeneville dam is about a mile and a half from the Thames. It was built in 1829, but has since been raised; it is a timber and stone structure, with stone abutments, and cost, say $50,000; the roll-way is 326 feet long and 14 feet high. Above is a pondage of perhaps 125 acres. The canal follows down the west bank, and is seven-eighths of a mile long, from 30 to 50 feet wide, and 10 feet deep.

The mills supplied with water are, in order, F. B. Durfee's grist-mill, the Hubbard paper-mill, and the mills of the Norwich Bleaching and Calendering Company, the Chelsea Paper Company, and the Shetucket Manufacturing Company (cotton goods). The total rated power of wheels in use is stated at 1,600 or 1,700 horse-power.

The privilege is operated by the Norwich Water-Power Company, which has sold absolutely to the various mills their rights to water, reserving a certain annual rental amounting to about $130 per 1,000-spindle power. Such measurements of water as are carried on are made at the gates opening from the canal. These gates are usually three in number at each flume, each gate-opening being 4 feet wide. In measuring, the gate is raised to a point leaving a small head between canal and flume; this head is measured, and the flow determined by formula. It is designed to introduce flume-measurements in time.

The privilege owned by the water-power company covers certainly 19 feet and 5 inches, extending from tide-water to the foot of what are known as the "Quinebaug falls", and an additional foot of fall is also claimed. The heads actually obtained at the mills range from 14½ to 17 feet, according to their position along the canal. So far as regards a thorough utilization of the power of the river, the plan of development adopted here is not the most desirable. If the dam could have been located considerably farther down-stream, and water carried to mills at tide-water, the entire benefit of the fall might have been received and the pondage substantially increased. The cost of the dam would have been greater, on account of its additional height; but, on the other hand, there would have been no necessity for building up a village separate from the city, as has been done at Greeneville.

At this point the Shetucket includes in its volume the water discharged by the Quinebaug. During high water the effective head at the mills is, of course, somewhat diminished by backwater, but not for more than one or two days in the year is the hindrance so great that they have to shut down. The common freshet depth on the dam does not exceed 6 or 7 feet. In the river below, the water sometimes rises nearly to the top of the canal bank, and has even been known to cover it from sight. The chief trouble is experienced from low water, and some of the mills use steam as auxiliary power. The supply of water is sufficient to run them all at full capacity six to seven months in ordinary years, and perhaps three-quarters capacity the remaining months. The pond is sometimes drawn

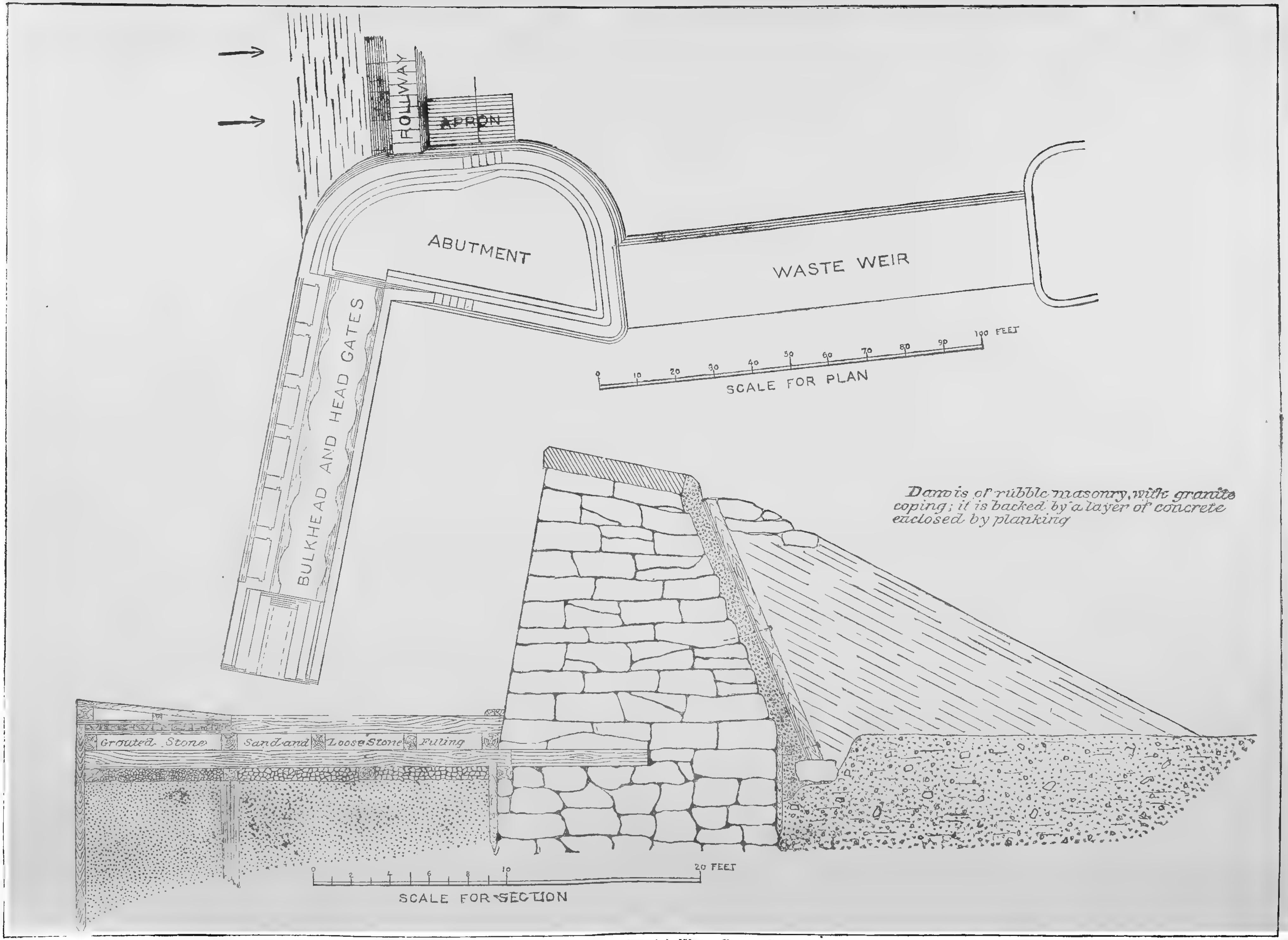

FIG. 4.– New Dam of the Norwich Water-Power Company.

down 18 inches, and there is seldom in summer any water running over the dam, even at night. During low stages a certain priority in rights to water exists; the Shetucket Company stands first, and must be supplied in preference to any of the other mills. The manufacturing concerns on this privilege are all of large size; they are conveniently located between the canal and the river, with the Norwich and Worcester railroad on the opposite side of the canal.

In September, 1881, work was begun upon a new dam at Greeneville, about 1,200 feet below the old one. The roll-way of this dam is to be 400 feet long; the masonry work is 15 feet high and is set slightly into the river-bed, its crest being on the same level with that of the old dam. The bed of the river is here composed of gravel containing cobble-stones or small bowlders, and retains that character to a considerable depth, probably 30 feet at least. The dam is 15 feet wide at the base and 7½ feet wide at the top; the face batters 2 inches, and the back 5 inches, to the foot. The work is in rubble masonry with cut-granite coping; the rubble is composed of a quartzose rock of varying composition. The back slope is to be faced with concrete to a thickness of 1 foot, secured in place by planking.

An apron of timber projects 22 feet below the dam. It has an upward slope at the down-stream end, attained by a "pitch-plank", designed to throw the water out and permit it to fall in such manner as not to produce scour in the river-bed at the end of the apron. The apron is of two thicknesses of timber, the intervening space filled in with sand and stone, except under the incline, where it is to be grouted stone. At the edge of the apron sheet-piling is driven 11 to 11½ feet into the river-bed; another row is driven 5 feet deep at the foot of the back slope of the dam. This precaution is to prevent leakage and scour under the structure. The material of the apron is hemlock at the bottom and yellow pine and oak at the top. The abutments are curving in plan, and built of rubble. The bulkhead is on the west side; it is of rock-faced masonry, and will contain six gate-openings, each 10 feet square.

Work on this dam was begun in September, 1881, as has been stated, but discontinued during the winter. The completed work was diked in, and no trouble experienced from high water. Upon the return of favorable weather work was resumed, and in August, 1882, was well advanced. At that time the upper dam diverted nearly all the flow of the river into the canal, and very little reached the work. The new structure was being built out simultaneously from both shores; it was expected to be completed during the fall, at an estimated total cost of about $60,000.

The next privilege is occupied by the Ponemah mill, at Taftville. This power is a short distance above the confluence of the Quinebaug and the Shetucket, and about 4 miles from Norwich. A spur from the Norwich and Worcester railroad, a mile and a quarter long, runs to the mill.

The river bed and banks are at Taftville composed mainly of gravel, and at a slight depth a sort of hard-pan is met, which affords the finest of foundations. One end of the mill rests upon rock, a kind of granite, which was quarried and worked into the foundations; a pocket of sand, which was used in making mortar, was also found on the site of the mill. There is no good brick clay in this section, however, and the bricks of which the mill is constructed were brought from Dayville, about 25 miles north on the Norwich and Worcester railroad.

The structure is indeed a splendid one. The main mill is 750 feet long by 74 feet wide, and 5 stories high, with an L 228 by 61 feet, and 4 and 6 stories high. It contains 108,000 spindles and has a capacity for about 2,500 looms. Another large building, to be used exclusively for weaving, was being constructed in 1882. Some 1,200 hands are employed, and with the completion of the new works the number will be increased to at least 1,500. The manufacture comprises more than 200 styles of lawns, cambrics, and fancy goods. Very fine numbers of thread are used, and it is said that no mill in the United States makes finer goods than the Ponemah; and still higher numbers of thread are before long to be employed. The enterprise of manufacturing was begun at Taftville more than ten years ago, but became embarrassed financially and the property was sold. The present company purchased while the mill was only partially complete, finished its construction, and stocked it with the very best machinery.

FIG. 5.—Ponemah mill at Taftville.

The dam has a novel shape, which has not been observed elsewhere on a scale of any importance. It consists of four elliptical sections, separated by piers. It is thought that in time the village in which the operatives live will have to be extended to the opposite side of the river, and the dam has been built in the manner described in order that the piers may serve to bear the superstructure of a bridge. The piers are 8 feet wide at the base and 6 feet at the top; the elliptical segments are each 100 feet in span, so that the entire length of dam between abutments is 418 feet, measured in a straight line; if we take into account the supplementary embankments and the bulkhead, (*a*) this length should be increased to about 800 feet. The dam is of rubble masonry, 16 feet wide at the base and 8 feet at the top, the coping-stones being a little shorter, however, or 6 feet; the height of the structure is 24 feet,

a The term "bulkhead" is used to indicate the masonry or timber work in connection with the head-gates at the entrance to a canal.

and the face has something of a batter. The apron is a heavy crib-work, 4 feet deep, and projecting 24 feet from the foot of the dam; the last few feet have an upward slope in the same manner as already explained in connection with the Greeneville dam. The west bank at Taftville is rock, while the river bed and east bank are gravel. In building the dam the river bed was excavated till a firm material was reached. The trench was then filled with sifted puddle, inclosing a line of sheet-piling which projects 4 feet below the bottom course of stone and is built into the masonry; there is also a line of priming at the end of the apron.

The abutments are very heavily built, of masonry, are curved in plan, and rise 13 feet above the crest of the dam. An embankment connects the west abutment with the bulkhead. The latter is constructed of granite masonry, has five 8-foot arched openings, and two parapets, it being used as a bridge. The hoisting-gear for the gates is operated by hand-wheels, which turn a horizontal shaft acting upon the different racks. The Taftville dam was built from 1867 to 1870, and its cost complete is roughly stated at about $100,000.

The canal is 50 feet wide at the bottom, 60 feet at the top, and inclosed by masonry walls. It has a total depth of 20 feet, 10 feet above and 10 feet below the crest of the dam, the additional depth being designed to carry freshet water and so prevent, as far as possible, loss of head from backwater. It runs from the bulkhead a short distance to the mill, passing under one end and continuing to the center, opposite which are located the wheels. The tail-water passes through arched ways under the head-race, and soon escapes into the river at the rear of the mill. The canal or head-race is 400 feet long from the head-gates to the center of the mill; the tail-race is 228 feet long and 60 feet wide. The short races employed here are to be noticed. The dam is located well down-stream on the privilege, giving a large pondage above; the water is promptly delivered to the wheels through a canal of ample dimensions, and quickly returned to the river again.

New water-wheels have lately been set, and comprise a Swain and two Collins turbines. At present, when running at full capacity, 1,200 horse-power is employed, the head on the wheels being about 25 feet. The entire fall, however, on the Ponemah privilege is 30 feet; the wheels have been set for that fall, which will be gained by excavating the shoals in the river below the mill.

The whole privilege, with 30 feet fall, is estimated at 1,500 effective horse-power in a low stage of the river, or sufficient for 115,000 cotton-spindles. In ordinary years full capacity can be run all the time by water, but in exceptional seasons, such as the summers of 1881 and 1882, the supply runs short for perhaps a couple of weeks; in such emergencies a 250 horse-power steam-engine is employed. With the present head the privilege is estimated never to fall below 1,100 effective horse-power, and for six or seven months in the year water wastes over the dam day and night. The pond sets back 2 miles up the river, but is never drawn down far, the policy being to maintain it nearly full, and so preserve the head.

The power next to be described is that at Occum, about 2 miles above Taftville. It is not on the line of any railroad, but is a little more than a mile from Versailles station, on the Providence division, and between 2 and 3 miles from Taft's station, on the Norwich division (*a*) of the New York and New England railroad. It is owned by the Occum Company, of Norwich, which has developed it with the view of leasing power to manufacturers. In 1880 a total of 180 (?) horse-power had thus been disposed of to two concerns—the Totokett cotton-mill and E. S. Farnham. The regular rate for power here is $20 per annum per horse-power. I estimate the available power of the privilege as follows:

Estimate of available power at Occum.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	Theoretical horse-power.		Effective horse-power utilized in 1880.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	14 *feet fall.*	
Low water of dry year	464	185	21.0	290	180 (?)
Low water of average year		230	26.1	370	
Available ten months in average year		300	34.1	480	

a By pondage along the stream the flow and power in low stages would probably be doubled for twelve hours in the day.

The improvements at Occum have been very substantially made. The work on the dam, abutments, bulkheads, and a river wall extending some distance down the west bank, is all of cement masonry. The dam itself is 12 feet thick at the base, 6 feet at the top, and 12 feet high; it is backed by gravel, paved on the slope with large flat stones. Supplementary to this part of the dam, which constitutes a roll-way 300 feet long, is 500 feet of earthen embankment, 20 feet high and 50 feet wide at the base. The apron is planked, and below it are large stones placed on the river bed to break the force of the water and prevent scour. There is a bulkhead, with head-gates, at each end of the dam, the design being to use power on both sides of the river. The mills now built are on the west bank, but any new mill would probably be located on the opposite side. The west canal is about 500 feet long, 40 feet wide, and 8 feet deep. The available fall at the mills is about 14 feet. Above the dam is a pondage estimated at 75 acres.

a Norwich and Worcester railroad—leased.

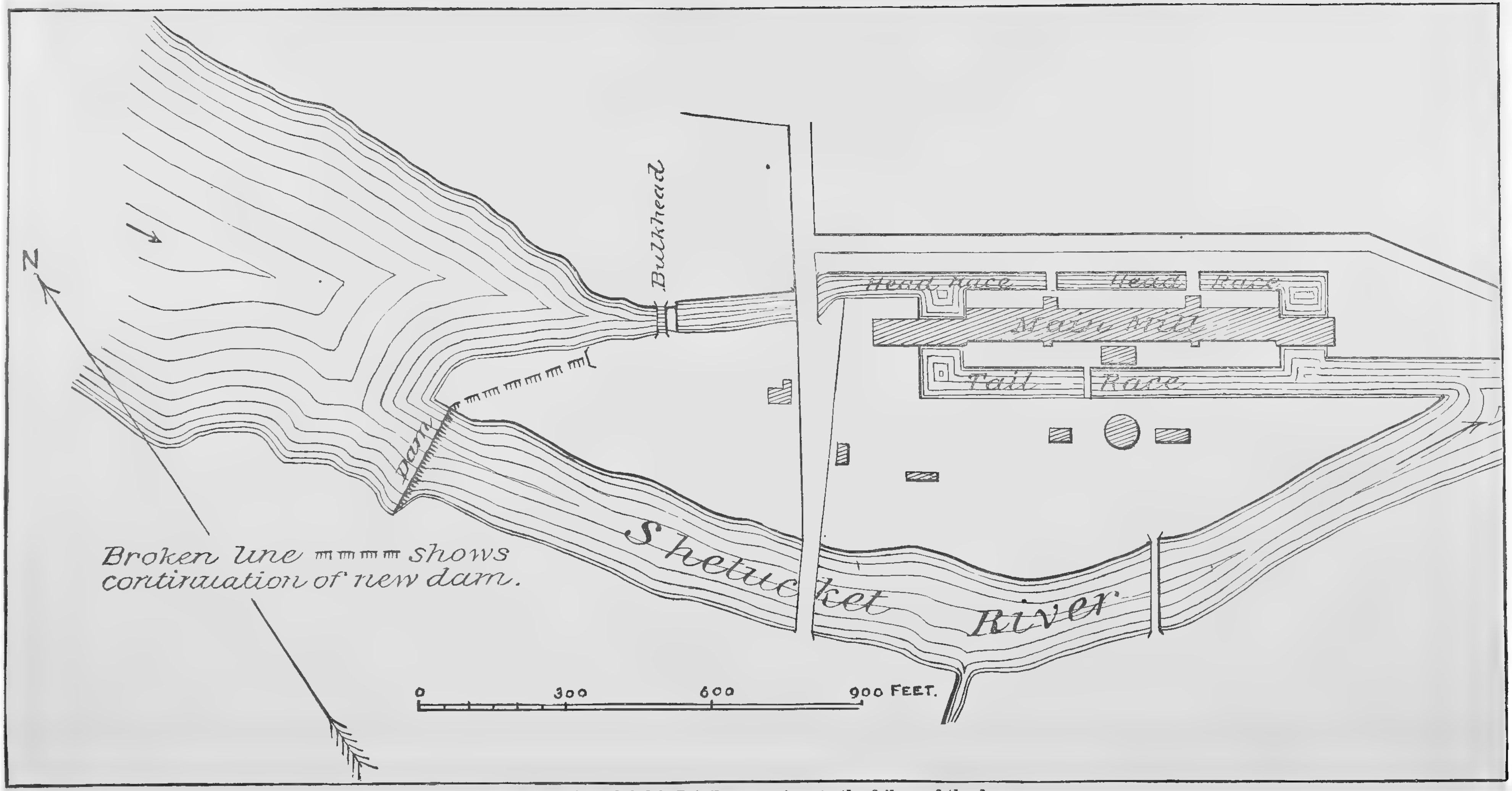

FIG. 6.—Plan of Baltic Privilege previous to the failure of the dam.

The Occum dam cost, in round numbers, $50,000. Work upon it was begun about the year 1865 or 1866. During its construction the company became involved in a lawsuit and was compelled to stop work; and a heavy freshet occurring about that time carried away part of the dam, with a loss of $15,000; and again, at the time of the Baltic disaster, it was damaged to the extent of about $27,000.

The last improved privilege on the Shetucket is the splendid one at Baltic, belonging to the estate of the A. & W. Sprague Manufacturing Company. It is at present leased by H. L. Aldrich, of Providence, for the manufacture of print cloths. The main building of the mill is 630 by 68 feet, and has two wings which increase the total length of the structure to 850 feet; it is 60 feet high and contains four principal stories, or six counting the basement and attic. In all 70,700 spindles are run, and 1,750 looms; 1,100 hands are employed, and when running full capacity, 142 bales of cotton are used per week.

The present dam was built in 1876. It rests upon a gravel bed, and abuts at the west end upon a natural ledge. The roll-way is 515 feet long, with a height of 24 feet above the river bed; it is 80 feet wide at the base and 4 feet wide at the top. The actual height of the dam, however, is much more than 24 feet, for the structure is carried down into the river bed some 20 feet. It consists throughout of a log crib-work, filled in with stone and puddled. The logs of the various courses are pinned together with iron pins. The face of the dam slopes rather more than the back, and is covered with 4-inch hemlock planking. The apron extends horizontally 17 feet from the foot of the slope, rests upon crib-work like that in the dam, and is covered with 8-inch white-oak planking. At the foot of the back slope, and again at the end of the apron, is priming, consisting of round white-oak piles, 8 or 10 inches in diameter, driven with a pile-driver as far down as possible.

Toward the west end the dam is pierced by a penstock, measuring 4 by 5 feet transversely, for drawing down the pond. The dam is obtuse-angled in plan, the apex up-stream. At the east end of the roll-way is a masonry abutment 37 feet 5 inches high from base of foundation, 80 feet long, and built 20 feet wide, of granite. From this abutment there runs a gravel embankment 180 feet long, 150 feet wide at base, 50 feet wide at top, and about 40 feet high, rising 16 feet above the crest of the dam; through its center extends a row of priming, like that already described, and driven down to about the level of the foundation of the roll-way, that is, some 20 feet below the river bed; at that depth hard-pan was struck. The roll-way of the dam is backed with gravel, paved with large flat stones for a considerable distance from the crest. The tendency of the water flowing over the dam is to form powerful eddies beside and against the masonry abutment. To guard against this a timber wall, some 4½ feet in height, has been carried down the front slope of the dam at an interval of, say, 20 feet from the abutment, shutting off the ordinary flow of water over that portion. A crib-work dike has also been extended some distance below the foot of the abutment and in a line with it.

At the inshore end of the embankment is the bulkhead, a fine piece of granite masonry. It is 80 feet long, 35 feet high, 20 feet wide at the base, and 11 feet wide at the top. Water is admitted to the canal through six gate-openings in this bulkhead. The bank adjoining the bulkhead, on the side away from the river, is a fine, sandy gravel, and at that end of the bulkhead priming was driven to a depth of 25 feet.

The head-race extends 700 or 800 feet from the head-gates to the mill, and then along past its whole front, giving a total length of, say, 1,500 to 1,700 feet; it is 50 feet wide, and carries an ordinary depth of 6½ feet of water. The tail-race also extends the whole length of the mill, in the rear, and then on to the river. Both head- and tail-races are walled with stone.

Power is taken from four Collins turbines (two 8 feet, one 5, and one 4½ feet in diameter), aggregating about 1,200 horse-power; these were stated to run under a head of 24 feet. Reliance for power is placed solely in water, steam not being used for that purpose. There has been a lack of water for running at full capacity not more than fourteen days in any one year. In the extreme drought which was being experienced at the time of my visit, in August, 1882, 850 effective horse-power was being realized, and I was informed by Mr. N. R. Gardner, the manager of the mill, that the river was then lower than he had seen it before in twenty years.

By flash-boards (a) the height at the crest of the dam can be increased 2 feet; the flowage is then approximately 500 acres. For four months in the year the water can be entirely ponded during the night; for six months it wastes both night and day. No trouble is encountered at this point from anchor-ice or from cake-ice. The latter, if allowed to form and break up in the canal, would bother at the rack at the entrance to the flume, but this trouble is obviated by a rude frame-work floating on the surface of the canal, dividing it into squares of a few feet on a side, and thus holding the ice.

Failure of the old Baltic dam.—The original dam at Baltic was a framed structure, open underneath. The roll-way was only 220 feet long, the embankment at that time extending to the apex of the angle in the present dam, or 295 feet farther than now. The abutment was of wood, and the bulkhead was also of wood, old and somewhat decayed. During the great freshet of March 26, 1876, a tremendous body of water came pouring down the river, till there was a depth of 15 feet on the roll-way. It finally broke through the bulkhead, filled, overflowed,

a So called in New England, but termed "brackets" in the West. They are boards fastened temporarily upon the crest of a dam, usually to a height of 1 to 3 feet, and designed to insure a larger storage in low water. They also increase the head so long as the pond remains up.

and gouged out the bank of the canal, and rapidly cut away the embankment of the dam, although the roll-way remained intact. The flood swept against the nearer end of the Baltic mill, of which over 90 feet was carried away, together with valuable machinery. An engine-house was destroyed, and the mill-races were filled with sand and gravel. The loss at this point probably exceeded $200,000, and $400,000 were spent in repairs outside of the mill, including a new dam, abutment, bulkhead, and embankment, clearing out the race-ways and lining them with stone walls.

Unimproved privileges.—I have now described all the improved powers on the Shetucket. There remain two privileges, undeveloped, and located, one at Scotland station, also known as the "Waldo privilege", and one at South Windham. Both belong to the estate of the A. & W. Sprague Manufacturing Company. The fall included in these two privileges may be regarded as about 54 feet, which agrees quite closely with the result to be obtained by deducting the fall belonging to the privileges below from the total fall of the river as shown by the survey of 1825. Ex-Governor William Sprague assigns 20 feet to the Waldo privilege and 34 feet to that at South Windham.

The Providence division of the New York and New England railroad follows down the east bank of the river past both privileges, and the New London Northern road also skirts the west bank at South Windham. Between Willimantic and South Windham the immediate valley of the Shetucket is rather narrow, seldom spreading to a greater width than half a mile to a mile. Hills of moderate height rise from the stream, and are succeeded by higher ranges farther back, only visible from an elevated point. The timber has been generally cut away, though quite large patches remain on the steeper slopes and on the summits of the higher hills. The soil is light and sandy or gravelly, and can be of but little value; the land seems to be used mainly for pasturage, but yields considerable grass and some corn and potatoes. From South Windham to Scotland the country is much more thickly wooded than above; much of the way the hills rise abruptly from the river, so that its immediate valley is narrow, with steep slopes.

At Scotland station the river is from 200 to 250 feet wide between banks. The bed is gravelly, and the banks are also gravelly in part, though sandy in places. Opposite the station they are perhaps 12 feet high. A shoal extends from this point a quarter of a mile, more or less, down-stream to Baltic backwater. In the vicinity of the station the ground bordering the river is flat for a considerable distance back on both sides. Near the foot of the shoals the west bank rises to a high, sandy and gravelly bluff, while the east bank sinks still lower than before, and forms low flats on which the ice is thrown out in spring. A quarter to a half mile above the station the hills close in on either side of the river, and give the only opportunity in this vicinity for a high dam. Thence down stream the east bank is favorable for a canal, except that a short distance above the station a brook puts in from the east. Mills would naturally be located on that side, as the ground is suitable and the railroad near at hand.

I found no record of any gaugings on the Shetucket river, but should estimate the power at this privilege as below. The rainfall on the basin of the river is approximately 11 inches in spring, 13½ in summer, 12 in autumn, 11 in winter, and 47½ for the year.

Estimate of power at Scotland station.

Stage of river.	Drainage area.	Flow per second. (*a*)	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*
Low water, dry year	*b* 420	170	19.3	390
Low water, average year		210	23.8	480
Available 10 months, average year		275	31.2	620

a Average for twenty-four hours. In low stages the flow and power would probably be doubled for twelve hours in the day.
b Above Merrick's brook.

At South Windham the river bed is gravelly and covered with cobble-stones. At the road bridge, which crosses at this point, there is quiet water, extending perhaps 1,000 feet still farther down stream, and succeeded by shoals reaching a long way beyond. Above the bridge a high gravel bluff rises from the river on the west side, and there is a similar one on the east side several hundred feet below the bridge; elsewhere the banks are from 10 to 12 feet high above low water, and succeeded by flat or gently sloping ground for some distance back. I was informed by a resident of the village that the design was to locate the dam, if the privilege were ever improved, opposite the upper bluff; if this were done, I should say that an embankment of considerable length would be required on the other side of the river. As regards building and convenience for shipping, the privilege is finely situated, with abundance of room, and two railroads close at hand.

FIG. 7.—View showing work of construction on New Baltic Dam.

Estimate of power at South Windham.

Stage of river.	Approximate drainage area.	Flow per second. (a)	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*34 feet fall.*
Low water, dry year	400	160	18.2	620
Low water, average year		200	22.7	770
Available 10 months, average year		260	29.5	1,000

a Average for the twenty-four hours. In low stages the flow would probably be concentrated within twelve hours, and, therefore, doubled for that time.

TRIBUTARIES OF THE SHETUCKET RIVER.

THE WILLIMANTIC RIVER.

The main river has a length of 21 miles, measured from its mouth to Stafford Springs; at that point it divides, and in the town of Stafford is made up of several small streams, some of them rising a short distance above the Massachusetts line. Its entire drainage area is 229 square miles. The old survey, previously mentioned, furnishes the only figures I have as to the fall, but it extended only a short distance above the mouth. Some of the localities mentioned in the survey are probably no longer known by the names there given.

Fall in the Lower Willimantic river.

[Survey of 1825.]

Section of river.	Distance.	Fall.
	Rods.	*Ft. In.*
Top Fingley's dam to cove below Lee's tail-race	66	18 9
Thence down the river	54	5 9
Thence to mouth of Byrne & Smith's grist-mill tail-race, including paper-mill fall	208	46 3
Thence to junction with Natchaug (a)	606	87 0
Total, top Fingley's dam to mouth	934	157 9

a Utilized at Willimantic.

In spring there is a heavy run of ice down the river, and gorges sometimes form above Willimantic. The stream is rapid to rise and fall; its drainage slopes are in general steep, underlaid at slight depth by rock, and shed rains quickly. Even in the driest season an ordinary summer shower will start water running over the Willimantic dams. A very high stage of water seldom lasts, however, more than three or four days; for that length of time during the year some trouble is met in the reduction of head, amounting, at the Windham Company's mill, to perhaps one-third of their total fall of 13½ feet.

Willimantic is the principal manufacturing point on the river. The borough contains between 6,000 and 7,000 inhabitants, is finely located, mainly on the right bank of the stream, and has good railroad connections by several lines.

The river is here, where running freely, from 60 to 100 feet wide, and presents very favorable sites for dams. The bed is composed almost entirely of rock ledges, showing a considerable dip to the south and southwest. Where there are no rock ledges the bed is covered with bowlders. The north bank is of good height, steep and rocky; the south bank is less abrupt, and all the mills are on that side. The surface materials in this section are quite variable; there are many ledges of rock, granitic in composition, but with the constituents very coarsely and unevenly mixed. Much of the stone, however, is of better quality, and resembles ordinary granite in general appearance, but is softer, and answers well for building. Most of the stone used for the buildings and dams of the Linen company was obtained either on the premises or close at hand. Bowlders and chips of granite are also found, even deep beneath the surface, and large "pockets" of sand; the Linen company procured sand for building purposes upon its own grounds.

There are six dams across the river at Willimantic, four stone and two framed. The mills are all fine structures of stone, and are located at the ends of the dams, races thus being dispensed with. Far the largest concern is the Willimantic Linen Company, which owns the four lower privileges. Its dams vary in length of roll-way from 125 to 225 feet. Beginning at the lowest, the falls on the successive privileges are 16½ feet, 22 feet, 11 feet, and 13 feet 7 inches. The total rated capacity of water-wheels is 1,150 horse-power, which can be realized about nine months in the year; during the rest of the time steam has to be used more or less. Very little water is ponded at these dams,

and the Windham company, farther up stream, is relied upon to hold the water during the night in its pond, which is of good size; this it is able to do for about four months in the year, but for eight months water wastes over the dam, and much of the time both day and night. The Linen company employs 1,500 hands and occupies the following principal buildings: No. 1 mill, part measuring 200 by 72 feet, and the remainder 60 by 80 feet; bleachery, 80 by 112 feet; dye-house, 140 by 70 feet; main mill, 407 by 70 feet; storehouse, 150 by 70 feet; No. 3 mill, 200 by 40 feet; No. 4 mill, 820 by 172 feet (uses 650 horse-power and is run entirely by steam); spool shop, 150 by 40 feet. The sole manufacture is thread, of which 27,000 pounds are made per week, from ninety to one hundred bales of Sea Island cotton being consumed in the same time.

Ascending the river, the next privilege is that occupied by the Smithville Manufacturing Company, manufacturers of cotton sheetings and silesias and running 21,000 spindles. Two wheels, aggregating 300 horse-power, are run under 11 feet head. The company also owns 3 or 4 feet of unimproved fall below the tail-race.

The uppermost privilege at Willimantic is that of the Windham Cotton Manufacturing Company, established in 1822. Eighteen thousand spindles are run in the manufacture of print-cloths. A fall of about 13½ feet is used, with water-wheels of 300 horse-power capacity.

Summary of water-privileges at Willimantic.

Company.	Fall.	Horse-power of wheels.	Remarks.
	Feet.		
Windham Cotton Manufacturing Company.	13½	300	Stone dam, roll-way 147 feet long. For six weeks in low water an average of about 150 effective horse-power is realized.
Smithville Manufacturing Company	14–15	300	Eleven feet fall in use. Employs steam-power in addition to water throughout the year.
Willimantic Linen Company (upper privilege).	13 7/12	270	Stone and cement dam. Steam used as auxiliary power in low water.
Do	11	220	Framed dam with inclined braces. Steam as auxiliary power in low water.
Do	22	500	Stone and cement dam. Steam used constantly for auxiliary power.
Do	16½	160	Framed dam. Water-power alone used.

Two important storage reservoirs in the Hop River basin are controlled at Willimantic. Columbia reservoir, flowing 282 acres, is controlled by the Linen company. It was formed by raising the water-level to a height of 25 feet above the natural water-surface in the stream at the dam; it will admit of being drawn down 22 feet, but does not fill regularly. Bolton reservoir is owned jointly by the three Willimantic manufacturing companies and the Hop River Warp Company. Its flowage is roughly estimated at 500 acres; it fills regularly, and, it is said, can be drawn down 8 feet from full water-line.

Passing above Willimantic, 13 feet fall and 150 horse-power are used by the Eagle cotton-mill at Eagleville, and at Mansfield and Merrow's Station falls of 10 feet each and small powers are also in use.

From Willimantic to Stafford Springs the country has a hilly surface, diversified by a moderate amount of timber. The immediate valley varies considerably. In some places it is narrow, with steep rocky slopes; in others wider, with a long, gradual rise to the summits of the hills. Narrow strips of grass-land border the stream at intervals, but are reported to be not very valuable. The stream itself is small, with a gravelly bed, and shows many riffles, with now and then stretches of quiet water. Through the intervales the banks are low; elsewhere they are not sharply defined, and are very variable in slope and height. The New London Northern railroad follows the river closely. There is considerable unimproved fall between Willimantic and Stafford Springs which would answer for powers of moderate size. It is mainly in the hands of farmers owning adjoining land, and they are said to be reasonable in their prices and anxious to have improvements made. At points toward Stafford Springs the valley is too narrow to be favorable for canals or buildings, but in the whole stretch of river considered several good privileges could doubtless be obtained.

TRIBUTARIES OF THE WILLIMANTIC RIVER.

Two principal branches, which for convenience may be termed the East and West, unite at Stafford Springs, Connecticut, to make up the main Willimantic river. Below the junction Rawitser Brothers have two small privileges, but the principal manufacturing is on the branches. The East fork has the more rapid fall and is much the flashier stream of the two. The West has a broader valley and carries more water; after a rain it usually continues to rise from six to twelve hours, and then gradually falls. It has two large reservoirs, and above the junction of the streams from Square and Orcuttville ponds there is an extensive wooded section from which one or two well-sustained little brooks proceed that materially assist this branch. Above their confluence the drainage areas of the East and West branches are, respectively, 20 and 36 square miles.

The East branch has a narrow valley much of the way, with steep rocky slopes, and while it continues rising so long as a storm lasts, on its cessation it immediately recedes and soon sinks to its former volume. Five miles

above Stafford Springs this branch is supplied by a reservoir owned by the Stafford Water Power Company, an association of mill-owners who hold stock in proportion to the amount of their fall. This reservoir contains 200 acres, and can be, and in some seasons is, drawn down 20 feet below full water-line; it has an extensive water-shed reaching 2 miles or more away, and always fills in spring. For two or three months the reservoir is drawn upon to supply the stream, but for the remaining time the natural flow alone is sufficient.

March 27, 1877, the old reservoir dam gave way, carrying with it all the dams, eight in number, and bridges on the stream below, causing a loss of two lives and a damage estimated at $100,000. The dam had been built under the charge of an experienced man. Work had been carried on, however, through the winter, when the material of the embankment was in a frozen condition; in spring it became soft, and a heavy rain coming on the whole went out.

The dams on this branch are, in Stafford Springs at least, of stone. The ponds are mainly small and are not relied upon for much storage, the flow of water being sufficiently well controlled at the reservoir. The fall seems to be about all taken up. There are mills at intervals all the way up to the reservoir, each mill clustering around it a little village of its operatives. The volume of water flowing in the stream is small, but the heads obtained are large; at the three lower mills, at least, breast and overshot wheels are used. Water is usually brought to the mills through races several hundred feet in length carried along the side-hills. The upper mills have to transfer goods and material to and from Stafford Springs by team. The village has a population of about 2,100, enjoys fair shipping facilities, and has considerable manufacturing importance.

Lower privileges on the East branch at Stafford Springs.

Company.	Fall employed.	Horse-power of wheels.	Remarks.
	Feet.		
Granite Mills	27	80	Lowest privilege. Stone and cement dam; roll-way 100 feet long and 22 feet high, with supplementary embankment 200 feet long. Small pond; race 800 feet long; breast-wheel used, and can generally be run at full capacity throughout the year; steam for auxiliary power.
Warren Woolen Company	25	100	Stone and cement dam about 25 feet high; race say ½ mile long; worsteds manufactured; two overshot wheels and from 20 to 30 horse-power of steam in use.
Glyn Company	19	50–60	Power located rather above the village; company manufactures cotton warps and yarns, employs 25 hands, and runs 2,200 spindles; dry-stone dam with gravel backing, built in 1877 at a cost of $5,000; roll-way 100 feet long, 17 feet high; overshot wheel used.
Riverside Woolen Company	26	84	Two or three miles above village; uses turbine wheel.

The areas of the reservoirs supplying the West branch cannot be definitely given. The Orcuttville reservoir is roughly described as about three-quarters of a mile long by half that breadth, and Square pond as nearly a mile each way. The former is owned by the Orcuttville company, using power at the outlet. It is reported that the company has the right to raise the pond 2 feet higher, and that it would admit of being raised 5 feet. Square pond is a natural lake raised 6 feet by a dam, and can be drawn down 7 or 8 feet. It is owned by Messrs. C. Fox & Co., of Stafford Springs. It is said to be possible to raise this pond 8 feet higher, but the site of the present dam has considerable quicksand, and would hardly admit of a higher dam in safety, without an excavation down to rock. This pond is fed to an important extent by large springs in its bed.

The lowest improved privilege on the West branch is that occupied by the 7-set mill of the Mineral Springs Company, manufacturers of cassimeres. This company has 14 feet head, uses 50 horse-power of water, which can be realized except in very dry seasons, and also employs 75 horse-power of steam.

Wangumbaug lake and outlet.—This lake is a beautiful sheet of water, with a surface variously estimated at from 400 to 600 acres. It lies toward the center of the town of Coventry, Connecticut, and drains easterly by a short outlet to the Willimantic. The drainage area of the lake alone is perhaps 5 square miles, and, including the outlet, not more than 7 square miles. Wangumbaug lake is a natural pond which has been raised by a dam. It can be drawn down 18 feet from high-water line, and for 13 feet below that line has a large flowage; in the remaining 5 feet its bottom shelves in rapidly. It depends largely upon springs in its bed for water, but the supply from all sources is insufficient to meet the demands of manufacturing, and the reservoir has not been full since 1872. It would admit of being raised still further than at present, but such a change would, of course, be useless. When visited, in August, 1882, the lake was furnishing about 500 cubic feet per minute, and was drawn down to within 2 feet of low-water mark. By a decree of court the maximum draught on this lake is limited, under a penalty of $10,000, to 720 cubic feet per minute, equivalent, at an efficiency of 70 per cent., to about 0.96 horse-power per foot fall.

The stream which runs down through the village of South Coventry is entirely dependent upon the lake for its supply. It has a rapid descent of 250 feet, in the 2 miles of its course, from low water in the lake to the Willimantic river, the fall being greatest toward the head. Its course lies through a narrow and beautiful valley, in which there is a succession of manufacturing establishments of small to medium size. The fall is nearly all taken up, but there is one privilege of 12 feet fall unimproved; there are also one of 12 feet and one of 18 feet, improved but unoccupied.

Water-privileges on Wangumbaug outlet (in order from the head).

Occupied by—	Fall.	Manufacture.	Occupied by—	Fall.	Manufacture.
	Feet.			*Feet.*	
White	14	Carriage-spokes.	C. H. Kenyon & Co.	13	Flannels (2 sets).
Wood	26	Shoddy.	do	26	Flannels (5 sets).
Tracy	18	Wool extract.	Parker	12	Privilege unoccupied.
Washburne	8	Silk.	Kingsbury	10	Saw-mill and wood-working shop.
Morgan	14	Silk.	Huntington	12	Silk.
Mason	7	Metallic cartridges.	Simpson	10–12	Privilege unoccupied.
Gilboa	30	Woolens (7 sets).	Rawitser Bros	18+	Privilege unoccupied; mill burned.
Wood	30	Woolens (2 sets).			

The eight establishments from Tracy's to Kenyon & Co.'s lower mill use steam as auxiliary power in low water. The time during which a full supply of water can be obtained varies so greatly in different years that no general statement as to its duration can be made. Kenyon & Co.'s experience for a single year was as follows: in 1881, ran by water till September; then shut off water entirely till January, 1882; then had nearly enough water all the time up to August. The ponds along the outlet are of no importance; Kenyon's pond is as large as any but would not supply the mill more than two hours. Teaming has to be done between the mills and the New London Northern railroad at the mouth of the stream; a spur track might, however, it is thought, be run up the valley to the lower mills, and would thus diminish the length of haul.

Hop river joins the Willimantic from the west 3 miles above the Natchaug. It has a drainage area of 50 square miles at Andover, and a total of 75 square miles above its mouth, the area lying entirely in Tolland county. From Hop River station to the mouth, some 3 miles, the immediate valley is rather flat, and the stream usually bordered by a strip of meadow grass-land. Farther back rise hills of good height, moderately timbered with a young growth. The New York and New England railroad follows the river, and is frequently close beside it.

The stream itself is from 50 to 75 feet wide in its lower course, and consists of a succession of rather sluggish pools joined by gravel shoals; in the pools the bed is muddy or sandy, and the adjoining banks are of the latter nature and a few feet in height above low water. The river rises rapidly after rains, and then falls away more gradually; the ordinary freshet-rise at Hop River station is perhaps 4 feet. Although from this point down the benefit is received both of the Columbia and the Bolton reservoirs, previously described, the volume sinks very low in the dry season. It is considered, however, that by raising the level of the Bolton reservoir the capacity of the stream could be substantially increased.

The Willimantic Linen Company owns 20 feet fall, extending up from the mouth, and holds it rather to protect its own water-power interests at Willimantic than for actual development. The only factory on Hop river is that of the Hop River Warp Company, William C. Jillson proprietor, about 3 miles from the mouth; 15 feet fall is used there, and 75 horse-power, which can be realized about nine months in an average year; for the rest of the time not more than from one-half to three-quarters of that amount is obtained.

The Natchaug river.—This stream unites with the Willimantic, to form the Shetucket, somewhat below the borough of Willimantic, and below all the mill privileges there. Its sources are in the towns of Union and Woodstock; its basin includes an area of 171 square miles, lying mainly in the western part of Windham county.

Fall in the lower Natchaug river.

[Survey of 1825.]

Section of river.	Distance.	Fall.	
	Rods.	*Ft.*	*in.*
Top of Swift's dam to foot of falls below mill	22	17	3
Thence down the river	366	12	3
Do	88	3	9
Do	82	3	8
Thence to mouth of river	454	14	8
Total from top of Swift's dam to mouth	1,012	51	7

The Natchaug is used considerably for small manufacturing, but its resources have not been thoroughly developed, and, as will be seen later, its reservoir capacity could be largely increased. One disadvantage to its use for power is that it is not very conveniently reached by any line of railroad. It runs, in its lower course at least, through a hilly country, well wooded, slightly cultivated, and sparsely settled. Its valley is comparatively narrow, and is a succession of intervales, between which the hills approach close to the water. The meadows of these intervales serve as grass-land of rather poor quality.

The fall is moderate, and is mostly made up of shoals, commonly located in the narrows between the intervales, while through the latter the flow is sluggish. The bed is variously composed of ledge rock, loose rocks or bowlders, gravel, mud, and sand, the two latter materials in the sluggish reaches. At Mansfield Hollow the stream falls abruptly over ledges of gneiss rock, which has also been quarried in the banks and used in the construction of a new mill.

At North Windham the Natchaug is 60 or 70 feet wide. The country which it drains seems to be well supplied with springs, and water is readily obtained by wells; nevertheless the stream is at present very unsteady; it rises rapidly, and at times a heavy rain will cause it to overflow the banks in twelve hours. Heavy freshets occur in spring, when the river submerges its banks and sometimes spreads out nearly a mile in width at favorable points, covering the valley from hill to hill. Cake-ice does not commonly cause much damage, still it is often thrown out on the flats in large amounts, and in some places gorges and chokes up the stream.

Near the mouth of the Natchaug the Willimantic Linen Company owns 10 feet of unimproved fall. The first improved power in ascending the river is at Mansfield Hollow, and is occupied by the National Thread Company, which takes skein thread from various factories in Massachusetts and Rhode Island and puts it up ready for market. Goods must be transported 4 miles by team to and from Willimantic, but this is not considered a serious disadvantage, the expense of cartage being not more than 6 or 7 cents per hundred pounds. The river at this point descends in a short distance 17 or 18 feet over rock ledges. At the head of the falls is a curved stone dam, forming a small pond above which would not supply the mill more than three hours. The head actually used is 14 feet, with 60 horse-power of wheels; this amount of power can be obtained throughout some years, while for two months in others not more than half as much can be realized. In the summer of 1882 a fine new stone mill was erected, three stories high, and measuring 155 by 52 feet in plan.

The next privilege is occupied by a small shoddy-mill at North Windham, having a low dam and a few feet fall. A short distance above, Messrs. E. H. Hall & Son have a mill at which they manufacture thread in skeins, though they do not put it up for market. The dam rests on a rock ledge, and is a stone and cement structure with a roll-way 200 feet long. The pond is large, extending a mile up stream, with an estimated average width of 300 feet. A fall of 11 feet is used, and a 60 horse-power wheel, soon to be replaced by one of 93 horse-power. Sixty horse-power can generally be realized nearly all the year; for two months the whole flow of the stream can be ponded at night, while for ten months there is a waste over the dam, and most of that time both night and day.

At Chaplin, 3½ miles above North Windham, there are four dams, with power used by two saw- and grist-mills, a paper-mill, and a pulp-mill. There are also several small mills in Eastford, still farther up stream.

In the lower part of the river there is thought to remain not much available fall. Two miles above North Windham 25 feet could be secured, with a large storage, as will be seen later, and at Chaplin there is 15 feet of fall unimproved. The power at these points may be estimated as below:

Estimate of power available near Chaplin.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	15 *feet fall.*	25 *feet fall.*
Low water, dry year	70–80	15	1.7	25	40
Low water, average year		25	2.8	40	70
Available 10 months, average year		40	4.5	70	110

Two reservoirs at present supply the Natchaug in the dry season—Crystal lake and Eastford reservoir. The former is a natural pond raised by a low dam, and is controlled by Kenyon Brothers, of Woodstock Valley; it contains 200 acres, and can be drawn down 7 feet. Eastford reservoir flows 200 acres, and can be drawn down 14 feet; it is owned by E. H. Hall & Son, of North Windham, and is sufficient to keep up the supply at their mill for six or eight weeks in low water.

It is said that the reservoir capacity of this river can be substantially increased, and in particular at the localities mentioned below; any improvements of this kind would benefit not only the Natchaug, but the entire course of the Shetucket:

(*a*) In the vicinity of Crystal lake a branch of the main river can be dammed and a large reservoir formed, into which Crystal Lake outlet would empty. It is roughly estimated that the combined flowage of Crystal lake and this new reservoir would be from 1,300 to 1,500 acres—certainly a large amount if realized—and that at least 6 inches of water could be assured at all times on Hall's dam at North Windham.

(*b*) In the northwest part of Chaplin a reservoir of 200 acres could be secured. The combined expense of constructing this and the one near Crystal lake, including flowage and dams, is placed at $30,000 or $40,000.

(*c*) Two miles above North Windham, on the main river, at an expense of not over $2,500, 250 acres could be flowed, with a maximum depth of 25 feet.

OTHER TRIBUTARIES OF THE SHETUCKET ABOVE THE QUINEBAUG.—*Little river* is a small stream joining the Shetucket from the left immediately below the Occum dam, and draining 41 square miles. Its only reservoirs are those formed along its course by dams at which power is used, but it is stated that there are good facilities for storage in its upper waters; at present it does not furnish much power except for a few months in the year.

The first privilege, a short distance above the mouth, is owned by Messrs. L. M. Heery & Co., manufacturers of cassimeres, worsteds, and suitings. They run 16 sets of cards and 5,640 spindles. Wheels are used aggregating about 175 horse-power, with a fall of 15 or 16 feet; these can be run at full capacity four or five months in the year, but during the remainder steam is used as auxiliary power.

Half a mile above, the Reade Paper Company has a pulp-mill, with 12 feet fall and 75 horse-power; and an equal distance still farther up stream a paper-mill, with 21 feet fall and 104 horse-power. During the severe drought of August, 1882, there was being realized, at the upper privilege, 24 horse-power twenty-four hours in the day. There are one or two woolen mills farther up stream, and 5 miles above the power last described the Reade company owns and holds for sale an unoccupied privilege having a good stone dam, 14 feet fall, and two turbine wheels.

THE QUINEBAUG RIVER.

This stream, the most important tributary of the Shetucket, may be said to have its origin in the town of Brimfield, in southern Massachusetts, although it receives there a number of small brooks from adjoining towns. Flowing southeasterly through the towns of Sturbridge, Southbridge, and Dudley, it enters Connecticut, and runs southerly through the eastern part of Windham county; passing into the northern part of New London county, it joins the Shetucket 3 miles above the mouth. It has a length of 49 miles below Southbridge, and a total length of 60 miles measured from the mouth of Mill brook, in the town of Brimfield, to its own mouth. Its drainage area includes 725 square miles. For the fall on this river the only source of information is, again, the old survey which has been referred to in connection with the Shetucket.

Fall in the lower Quinebaug river.

[Survey of 1825.]

Section of river.	Distance.	Fall.		Remarks.
	Rods.	*Ft.*	*In.*	
From top of Danielson's old dam, 4 rods above Killingly bridge, to Pierce's bridge, between Brooklyn and Plainfield.	1,448	52	11	Fall now improved by dams.
Thence down stream to mouth of Packer-and-Lester or Varnum's brook.	2,501	28	8	As nearly as may be estimated, about 3 feet of this, next below Pierce's bridge, is taken up by the Wauregan mill-privilege. With this assumption the fall from the top of the Danielsonville dam, as claimed for the improved privileges, amounts to about 2 feet more than as shown by survey; possibly due to flash-boards or other increase in height of crest of the Danielsonville dam since the time of the survey. Deducting 3 feet, there remains 25 feet 8 inches, constituting what is known as the "Packer" or "Canterbury" privilege, which is unimproved.
Thence down stream to mouth of Pachaug river	1,922	26	3	Unimproved.
Thence down stream to mouth of Morgan's brook	1,171	15	1	The tail-race from Slater's mill on the Pachaug is stated to take up 2 feet 4 inches of this fall; the remainder is unimproved.
Thence down stream to foot of Quinebaug falls	688	38	3	Unimproved.
Thence down the Shetucket river to tide-water at Norwich	850	19	5	Owned and improved by Norwich Water Power Company, which is also said to claim 1 foot more fall.
Total fall from top of Danielson's dam to tide-water in the Shetucket.	8,580	180	7	

Although the descent of the river is moderate, amounting to less than 7 feet per mile for the distance above mentioned, it is sufficient to carry off freshet waters promptly and prevent serious hinderance to the mills from backwater. They all suffer slightly from a temporary reduction of head during freshets, but an extremely high stage seldom lasts more than half a day, and only in rare cases renders necessary a stoppage of work; the Monohansett mill at Putnam has been shut down by backwater only once in ten years. The large number of storage reservoirs and mill-ponds in the Quinebaug basin holds back the water of storms and melting snows, and very much modifies the violence of freshets. The ordinary freshet-rise where the river is running freely, below the dams, throughout the length of the Quinebaug, does not exceed from 3 to 6 feet, and only in extraordinary cases does it amount to 8 or 9 feet. At Wauregan the highest rise in four years previous to 1882 was 5½ feet. Steam is in common use as auxiliary power during periods of low water, at various points both on the Quinebaug and on its tributaries. The necessity for this has not arisen from any inferiority in these streams as compared with streams in general, nor does it seem to be due to a gradual failure of the water-courses from the cutting of timber, but rather to greater demands having been made than the low-water capacity of the streams was calculated to meet. Doubtless the natural dry-season flow, if that could be determined, would be found less now than fifty years ago, owing to the clearing of timber and the drainage of swamps; but that diminution is disguised and has been overcome by the extensive building of storage reservoirs. Although these improvements have been of great benefit in

sustaining the streams, mill-owners have gone on adding to the machinery in their mills, and driving it all at greater speed than formerly, until they have outstripped the capacity of their water-privileges for furnishing constant power.

It would be of interest to be able to give a complete list of all the storage reservoirs in the Quinebaug basin, with their areas accurately determined, but the latter, at least, is impracticable; many of the reservoirs are natural ponds which have been raised and whose areas have not been measured. Such maps as could be obtained are rather old, and either do not show many of them at all, or else represent them with areas very different from what they now have. It has been necessary, therefore, to rely in many cases upon estimates of their size; in doing so the best authority has been sought—that of those owning or controlling the reservoirs and presumably familiar with their capacities. The following table presents the results of these inquiries; it may be relied upon as including all the more important storage reservoirs tributary to the Quinebaug, and as giving the areas of most with tolerable accuracy:

Principal storage reservoirs in the Quinebaug basin.

Name.	Locality (town).	Approximate area.	Stream supplied.	Remarks.
		Acres.		
Pachaug reservoir	Griswold, Connecticut	900–1,000	Pachaug river	Entirely artificial.
Beach pond	Eastern part of Voluntown, Connecticut.	1,000–1,200	do	Area estimated.
Billings pond	Northern part of North Stonington, Connecticut.	100	do	
	Plainfield, Connecticut	100	Moosup river	Unoccupied privilege on Moosup river owned by Aldrich, Milner, & Gray; area estimated.
Moosup pond	Northeastern part of Plainfield, Connecticut.	600–700	do	Area estimated.
Oneco pond	Oneco, Connecticut	125	do	Unoccupied privilege.
Nashawaug reservoir	On Quinebaug, above Wauregan, Connecticut.	75	Quinebaug river	Area estimated roughly.
Old Killingly pond	Eastern part of Killingly, Connecticut	200	Whitestone brook	Area estimated.
Edy reservoir	Killingly, Connecticut	60	do	Do.
Simmons' reservoir	do	65	do	Area by survey.
Middle reservoir	do	100	do	Area estimated.
Bog Meadow reservoir	do	30	do	Do.
Wakefield pond Quaddick pond	Eastern part of Thompson, Connecticut.	1,500	Five-Mile river	Do.
Keach's reservoir			do	
Alexander's pond	Northwestern part of Killingly, Connecticut.	216	Short stream to Quinebaug	Area measured on old state map.
Woodstock pond	Eastern part of Woodstock, Connecticut.	86	Muddy brook	Do.
Hayden pond	Eastern part of Dudley, Massachusetts	93	Small stream emptying into French river and used for power by the Stevens' Linen Works.	Areas by survey.
		25		
Larned pond		34		
Peter pond		44		
Merino pond		83		
Chaubunagungamaug lake	Webster, Massachusetts	1,300	French river	Areas as given by H. N. Slater, esq., president Slater Woolen Company.
Robinson pond	Oxford and Sutton, Massachusetts	100	do	
Sacarap reservoir	Oxford, Massachusetts	125	do	
Charlton or Granite reservoir	Charlton, Massachusetts	240	do	
Pierpont Meadow pond	Northeastern part of Dudley, Massachusetts.	100	do	
Platte pond	Charlton and Oxford, Massachusetts	125	do	
Styles' reservoir		400	do	
Burncoat pond	Western part of Leicester, Massachusetts.	142	do	Area by survey.
Cedar Meadow pond	Leicester and Spencer, Massachusetts	153	do	Do.
Mashapaug pond	Union (northeastern part), Connecticut	225	Upper Quinebaug river	Areas as stated by Hamilton Woolen Company, which controls the reservoirs.
Holland pond	Holland, Massachusetts	445	do	
Cedar pond	Sturbridge, Massachusetts	100	do	
Walker pond	do	100	do	
Hatchet pond		40	do	
Big Alum pond	Northwestern part of Sturbridge, Massachusetts.	200	do	Area by survey.
Little Alum pond	Eastern part of Brimfield, Massachusetts.	73	do	Do.
Long pond	Western part of Sturbridge, Massachusetts.	139	do	Do.
Total		9,443–9,843		Total number of reservoirs in this list, thirty-nine.

It is safe to say that, in round numbers, there are now about forty reservoirs in the basin of the Quinebaug, covering an aggregate surface of 9,000 or 10,000 acres, exclusive of the storage in ordinary mill-ponds along the streams where power is in constant use. Large as this development has become, there is yet opportunity for considerable increase in storage, though mainly in the lower basin. The areas drained by the Pachaug and Moosup still offer favorable sites for extensive reservoirs, but, so far as can be learned, they are the only sections that do offer such sites. The Five-Mile River and Whitestone Brook basins seem to be thoroughly developed as regards storage. It is stated on good authority that there are no opportunities for substantial increase of reservoir capacity about the headwaters of the main Quinebaug. As for French river, H. N. Slater, esq., of Webster, a gentleman probably more familiar than any other with the stream itself and the country it drains, is of opinion that the aggregate capacity of the present reservoirs might be increased 10 or 15 per cent., but that any greater increase, and especially the building of any more reservoirs, is out of the question—they would not fill if built.

DESCRIPTION OF WATER-POWERS.—There is undoubtedly no other locality in extreme southern New England where there is so much well-situated and valuable water-power unimproved as within a dozen miles of Norwich. The two privileges on the Shetucket below Willimantic have already been described, and now, taking up the Quinebaug, there are four valuable undeveloped powers in succession to be noticed as we ascend that stream, before we meet a single one that is improved. Probably it is the very fact that they are large and valuable that has prevented their being taken up for manufacturing purposes. The tributaries of the Thames, and especially the Quinebaug and its affluents, have become established and of great importance as cotton-manufacturing, and, to a less degree, as woolen-manufacturing streams. The development of the privileges alluded to would very likely be for the former industry; but the improvement of such large powers for cotton manufacturing would imply the outlay of a great amount of money, and it is only at considerable intervals that enterprises of such magnitude are undertaken. Nevertheless, it is generally considered that it is the large powers which are most profitably improved, and it is to such that the most attention seems now to be given in New England. It is probably only a question of time as to the development of the fine water-privileges in the vicinity of Norwich; they are now in the hands of wealthy parties who appreciate their value, and who are not disposed to sell except at favorable prices.

From the mouth of the Pachaug to tide-water in the Shetucket there is a fall of 72 feet 9 inches; of this, 2 feet 4 inches are taken up by the tail-race of John F. Slater's mill on the Pachaug; the Norwich Water Power Company covers 19 feet 5 inches, and claims another foot; there remain, then, 50 feet of available unimproved fall between the top of the Greeneville dam and the foot of Slater's tail-race. These 50 feet are divided between what are known as the "Tunnel" and "Bunda Hill" privileges. The latter privilege is owned by the heirs of the late Robert G. Shaw and by Messrs. A. Lockwood Danielson, J. De Forest Danielson, and A. D. Lockwood, the last named gentleman of Providence. The fall is stated to be about 15 feet. The Tunnel privilege is owned by the Shetucket Manufacturing Company, of Norwich, and includes the remainder of the fall, amounting under the above assumptions to 35 feet. Its name comes from the fact of the principal falls being near a short tunnel on the Norwich and Worcester railroad.

Passing up the Quinebaug from the point where it joins the Shetucket, its width quickly contracts and rapids begin. In the lower half-mile there is a descent of 19 feet, and from opposite the tunnel for 1,000 feet, more or less, the river rushes down through a narrow rocky gorge. Along the west bank is the railroad, 25 or 30 feet above the river, and supported by a heavy retaining-wall. The east bank rises with a steep rocky slope from the water, the ascent becoming rather more gentle in the last few hundred feet above the river's mouth. Immediately above the tunnel the stream widens out and a continuous shoal stretches steadily up its course; the east bank now rises more gradually than in the narrows, and appears much more favorable for canal and building improvements. The general character of the stream and its banks then continues without great change up to Jewett City.

The Tunnel power might be improved either as a whole or by dividing it into two privileges. In either case it would be impracticable to build a dam of sufficient height in the narrows, as it would cause overflow of the Norwich and Worcester railroad during freshets. If the privilege were improved in one fall, a dam would have to be located above the narrows and water brought down in a canal; if it were divided, two dams would be required, one above and the other below the narrows. A magnificent power could be obtained by combining in one the entire 50 feet of fall belonging to the Tunnel and Bunda Hill privileges; a dam would have to be located at some point up-stream, and a long canal run down the east bank. A canal of much length would probably encounter considerable ledge rock, especially at the narrows, but much of the material excavated could be used in building the mills. It is considered by good judges that the development of the 50 feet fall in this manner would furnish power sufficient to drive from 250,000 to 300,000 cotton spindles, according to the number of yarn spun, and if it were so utilized would build up a village of 5,000 or 6,000 inhabitants, and add largely to the value of adjoining land. The mills and village would need to be located on the east side of the Quinebaug; they would be within 3 miles of tide-water, but the site has the present disadvantage of being without any railroad, the Norwich and Worcester road lying across the river.

No gaugings of the Quinebaug could be learned of, but the power at these privileges may be estimated as follows:

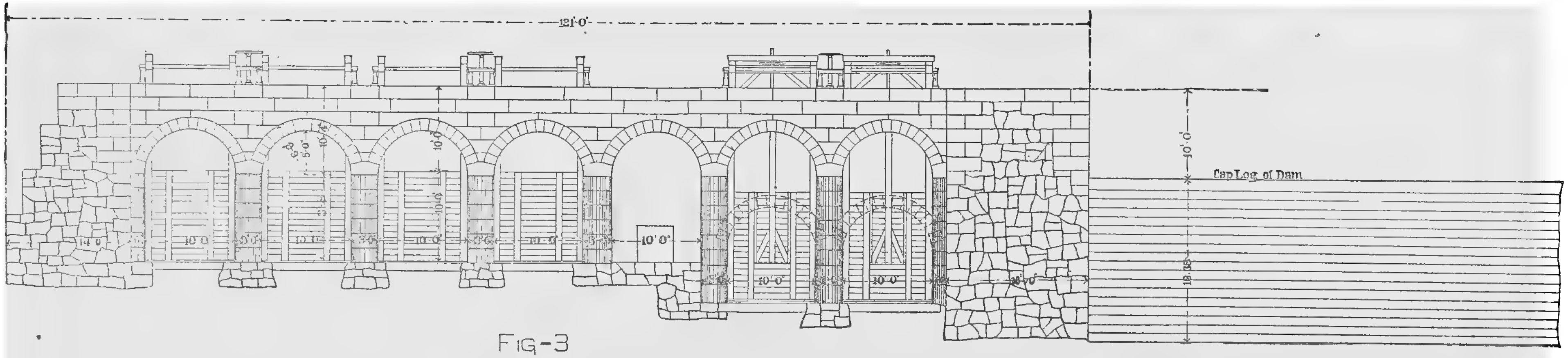

Fig-3

ELEVATION

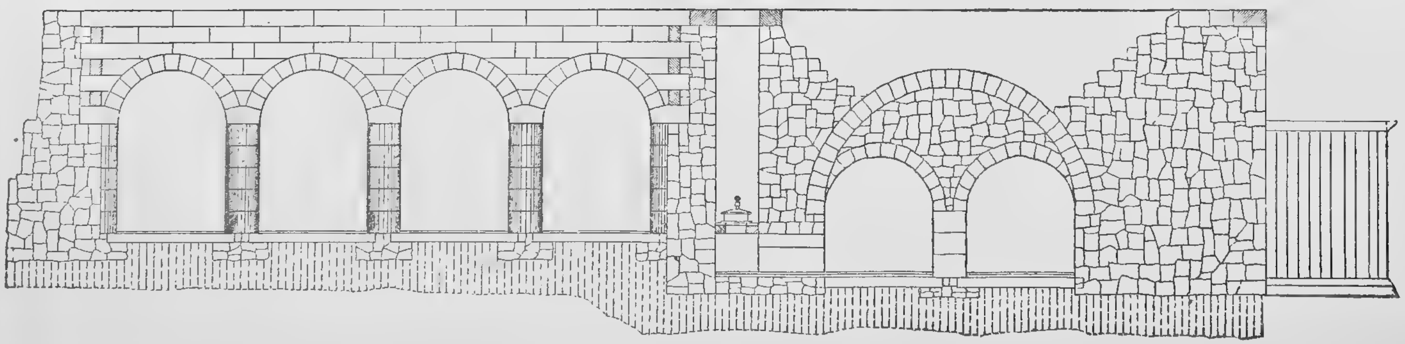

Fig-2

LONGITUDINAL SECTION

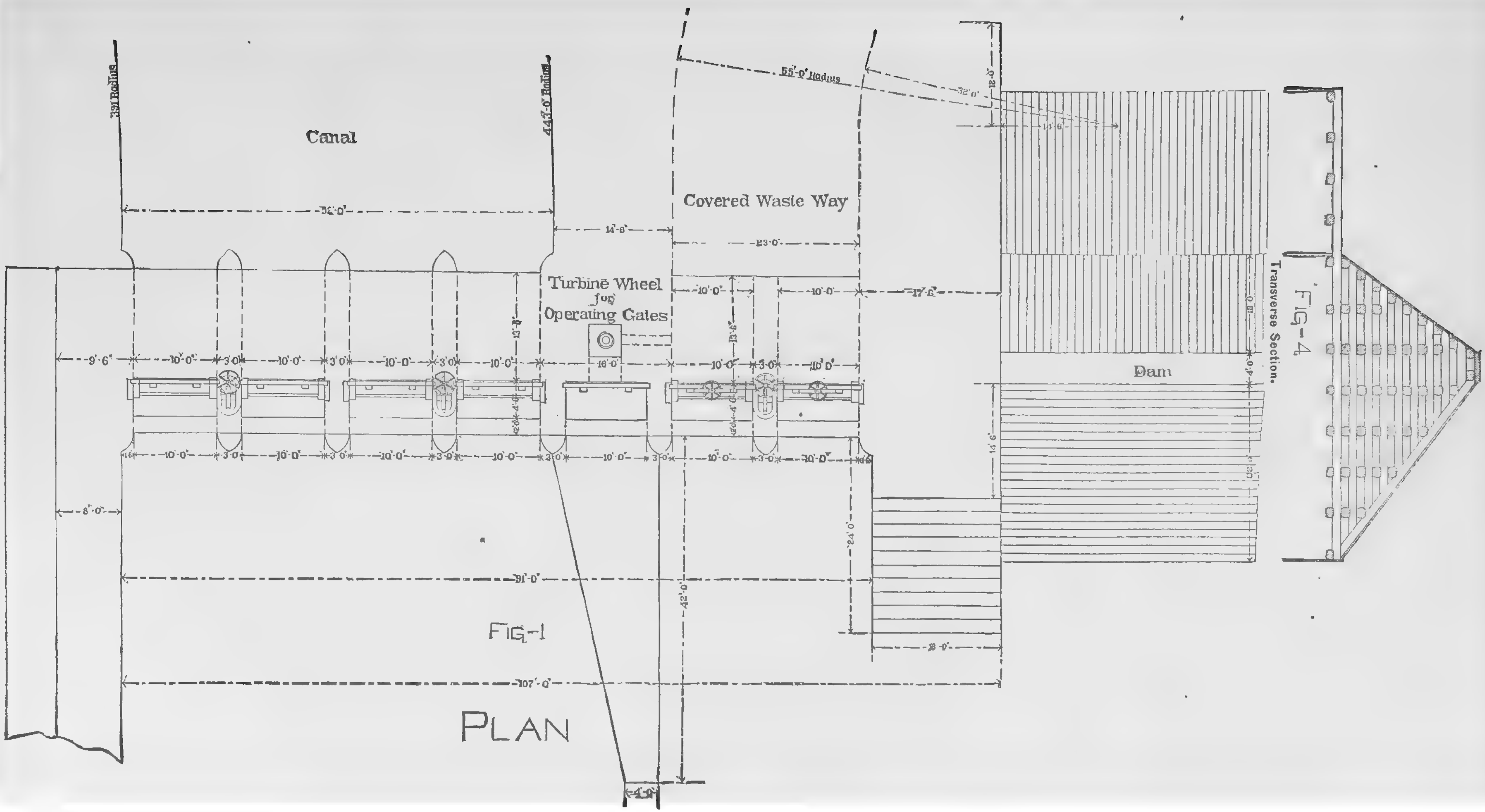

FIG. 9.—Nashawang Water-Power, Wauregan Mills, Plainfield, Connecticut.

Estimate of power at Tunnel and Bunda Hill privileges.

[Bunda Hill assumed at 15 feet, and Tunnel at 35 feet.]

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	Theoretical horse-power.			
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*15 feet fall.*	*35 feet fall.*	*50 feet fall.*
Low water, dry year	725	310	35.2	530	1,230	1,760
Low water, average year		360	40.9	610	1,430	2,050
Available 10 months, average year		455	51.7	780	1,810	2,590

a In low stages of the river the flow could probably be doubled for twelve hours in the day.

NOTE.—The rainfall on the basin of the Quinebaug is 11 inches in spring, 12 in summer, 11 in autumn, 11 in winter, and 45 for the year.

The next power on the river is situated at Jewett City, a little way above the mouth of the Pachaug. It is commonly called the "Jewett City" privilege, and is owned by Mr. Charles Johnson, of Norwich. In location and convenience of development it is undoubtedly superior to any other unimproved privilege on the Quinebaug or Shetucket. Jewett City is an old established manufacturing village, with stores, churches, and schools, and contains the extensive cotton-mills of Mr. John F. Slater and the Ashland Cotton Company, run by power from the Pachaug. The Norwich and Worcester Railroad station is less than a quarter of a mile from the falls, and the track runs within a few hundred feet of them. The falls are caused by a chain of partly submerged rocks extending across the river, over which there is an abrupt pitch of a couple of feet; rapids also extend for some distance farther down stream. Above the falls there is smooth water, though apparently with a good current, the adjoining banks wooded and of moderate height. Within 150 feet of the falls the west bank becomes steep, and is perhaps 50 feet high; it continues thus for several hundred feet, past the falls, and then becomes more gentle, the hills receding. The east bank has an easy slope all the way past and below the falls. Where these occur the main channel of the river is probably not more than 100 feet wide; a low rocky island extends a short distance up and down stream, and lies within a few feet of the west shore. Opposite the lower part of the island there rises abruptly on the east shore a mass of ledge rock 10 or 12 feet high above the water, reaching 75 feet along the stream and 25 feet inshore. Inside of this ledge a rocky slope with a scanty covering of soil ascends gradually, as if from the water's edge.

Mr. Johnson's privilege is stated to embrace an entire fall of about 23½ feet. The natural plan of development would be to construct a dam say 18 feet high at the crest of the falls, and carry a short race down the east bank, where there is abundant building room, with the railroad close at hand. The site for the dam offers perfectly secure foundations of solid rock; it is estimated that a substantial timber structure, 18 feet high and 300 feet long, could be built for from $25,000 to $30,000. It would set the river back for 4 or 5 miles above, and provide a pondage, as claimed, of about 500 acres. The privilege is rated as sufficient in power to drive 90,000 spindles, No. 30 yarn. My own estimate of the available power in different stages of river is shown below:

Estimate of power at Jewett City privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	Theoretical horse-power.			
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*18 feet fall*	*23½ feet fall.*	*26½ feet fall.* (*b*)
Low water, dry year	635	240	27.3	490	640	720
Low water, average year		290	32.9	590	770	860
Available 10 months, average year		370	42.0	760	990	1,100

a In low stages of the river the flow could probably be doubled for twelve hours in the day.
b Total unimproved fall in river from mouth of Varnum's brook to mouth of Pachaug.

The last of the unimproved powers which have been alluded to as lying within the vicinity of Norwich is known as the "Packer" and also as the "Canterbury" privilege. It is situated between the towns of Plainfield and Canterbury, extending from the mouth of Varnum's brook to the tail-race of the Wauregan mill, and is variously stated to include from about 26 to a little over 30 feet fall; if we allow 3 feet below Pierce's bridge to the Wauregan privilege, there remains, according to the survey of 1825, 25 feet 8 inches of fall to the Canterbury privilege. It is a good power, but much less favorably located than that at Jewett City, the railroad being farther away and there being only a few scattered farm-houses near at hand. The present owners are Messrs. E. A. & Daniel Packer and William A. Healy, the latter of Hartford.

Estimate of power at Canterbury privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*25.7 feet fall.*
Low water, dry year	590	225	25.6	660
Low water, average year		270	30.7	790
Available 10 months, average year		340	38.6	990

a In low stages of the river the flow could probably be doubled for 12 hours in the day.

At Wauregan, 21 miles by railroad above Norwich, is met the first power in use on the Quinebaug river. It is occupied by the Wauregan Mills, running 56,000 spindles in the manufacture of sheetings and fancy cotton goods. The dam was originally built in 1853, but was rebuilt in 1876, and its cost is stated at $27,000. The roll-way is 350 feet long, and consists of a log crib-work filled in with loose stone. The logs are 5 or 6 feet apart, from center to center, in both directions; two or three of the lower courses are set down into the river-bed, and all are carefully fastened together with iron pins. The ends of the logs are adzed to give flat bearings. Priming, or sheet-piling, is driven into the river-bed at the foot of the front and back slopes and at the end of the apron, to prevent water from working under the dam. The top of the structure has a width of 4 feet, and is perhaps 16 feet above the river-bed. The back slope has a base of 21 feet and the front slope a base of 11 feet, making the width at base of the main portion of the dam 36 feet. The face and top are covered with 4-inch oak planking and the back slope is covered with 3-inch chestnut. An apron projects down-stream 23 feet from the foot of the front slope, and consists of 5-inch oak planking, covered part of the distance with a less permanent layer of planking 2 inches thick; this is designed to receive the impact of overfalling ice, and when worn out can easily be renewed. The river-bed here is gravelly.

From the dam a canal, say 1,000 feet long, 50 feet wide, and 7 or 8 feet deep, conveys water to the mill, where it is used under 17 feet head, with wheels of about 900 horse-power. For a month or six weeks in the year there is a shortage of water, during which an average of about 700 horse-power is realized. The pondage is sufficient to control the low-water flow of the stream, and there is very little waste over the dam in summer; during that season the pond is usually drawn down 8 or 10 inches through the day, and fills again at night.

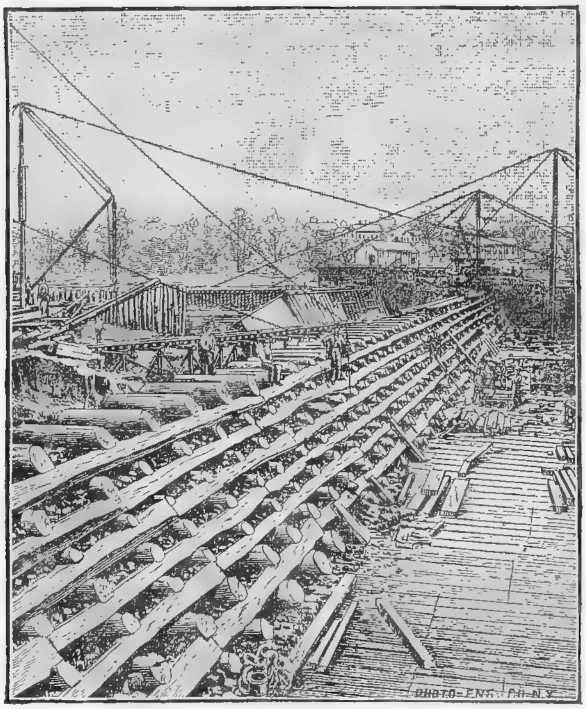

FIG. 8.—New Wauregan dam on the Quinebaug river, during construction.

Immediately succeeding this privilege, and distant 2½ or 3 miles from Wauregan, is the upper privilege owned by the same company. It is called the "Nashawaug" power, and is at present used only for storage purposes; it is held, however, to meet the future needs of the company, and is in condition, with completed dam and suitable gates, for use in manufacturing at any time. The fall covered by this privilege is 17 feet. The dam has a roll-way of about 350 feet, and in cross-section and general construction is a close copy of the one at Wauregan. The width at base of the dam proper is about 37½ feet, and the crest is 16 or 17 feet above the upper surface of the apron; the latter projects 20 feet from the front slope, instead of 23 feet as at Wauregan. The abutment next the bulkhead is 17½ feet wide, at right angles to the stream, and is of granite masonry. The bulkhead is built of granite ashlars backed with rubble in cement, and has a length in the clear, between the abutment of the dam and the shore-wall, of 88 feet. In this distance there are seven arched openings, each 10 feet in width, and separated by piers 3 feet thick; the two openings next the river connect with a covered waste-way, the third is to supply a turbine for operating the gates, and the remaining four are for the purpose of admitting water to the canal. The Nashawaug power is a fine one, and the dam and connecting works have certainly been built in a very substantial manner.(*a*)

The next power is at Danielsonville, a thriving borough of about 3,100 inhabitants, 27 miles by river and about the same by railroad from Norwich. Cotton manufacturing is carried on here both on the Quinebaug and on Five-Mile river. On the former stream the Quinebaug Company has a fall of 24 feet, and uses a total of 935 horse-power at two mills; the wheel capacity, however, is stated at probably 1,200 horse-power, being large enough to

a Drawings of the dam and bulkhead were kindly furnished by Messrs. Thompson and Nagle, engineers, of Providence.

insure power during a reduction of head by high water. This privilege receives the benefit of the water used from Five-Mile river by the Danielsonville Cotton Company, whose tail-race discharges above the Quinebaug Company's dam. The latter company experiences considerable trouble in winter from anchor-ice. Its canal is 600 or 800 feet long, rather shallow, and has a stony bottom. During the winter season a man is sometimes required for two or three hours every morning, for a period of three or four weeks at a time, to rake the ice away from the racks at the entrances to the flumes. The difficulty disappears as soon as the water-surface becomes solidly frozen over. The Quinebaug Company manufactures cotton sheetings and runs 51,500 spindles. The supply of water is sufficient during all but about two weeks in the year. In the summer of 1882 steam was being introduced into the old mill for auxiliary power in low water; this mill stands intermediate on the line of the canal, and has but 14 feet head.

Three and one-half miles, by river, above Danielsonville, the Williamsville Manufacturing Company, running 550 looms in the manufacture of cotton goods, uses a fall of 9½ feet. This company also owns an unimproved privilege, perhaps a mile and a half above, which was used by a saw-mill many years ago, and some of the timbers of the old dam are still visible. The fall belonging to this privilege was not ascertained.

The next manufacturing place is Putnam, one of the most important points on the Quinebaug, and located at the junction of the Norwich and Worcester (*a*) and main line of the New York and New England railroads. There are three fine powers here, all largely used. The lowest in order covers a fall of 32 feet 10 inches. It was originally owned entirely by Thomas Harris, of Providence. Mr. Harris has sold one-half the privilege to the Putnam Woolen Company, one-quarter has been leased to the Monohansett Company, and one-quarter still remains available for other manufacturing. A three-story wooden building, 104 by 54 feet in plan, provided with a 164 horse-power wheel, and adapted to manufacturing purposes, has been erected but not yet occupied, and Mr. Harris is prepared to put up other suitable buildings for those wishing to obtain power.

FIG. 10.—Falls in the Quinebaug river at Putnam.

The dam at this privilege is largely natural, consisting of huge ledges which almost choke up the stream, and which are connected by short lengths of framed work. On the west bank are the large mills of the Putnam Woolen Company, while on the east bank a race probably 1,000 feet or more in length conveys water to the mill of the Monohansett Company, manufacturers of cotton goods. The entire privilege is estimated at about 800 effective horse-power in ordinary low water. It is dependent in the dry season upon the running of the mills above, as the pondage here amounts to but a few acres.

The middle privilege at Putnam includes 18 feet fall, of which only 16½ feet has been developed. The dam is a stone and cement structure, with a roll-way 157 feet long, 18 feet high, 22 feet wide at base and 8 feet at top; it was built in 1861, at a cost of about $10,000. Power is used on the east side by the Nightingale mills, cotton goods, 13,000 spindles, 160 horse-power, and on the west side by the Morse mills, cotton-goods, 13,000 spindles, 160 horse-power.

The upper privilege at Putnam is occupied on the east side by the Powhatan mills, running 20,000 spindles on cotton goods, with 15½ feet head and 200 horse-power; on the opposite side is the Putnam Manufacturing Company, cotton goods, with the same head and about the same power. Each concern owns one-half the privilege. The dam is built of stone in cement, with roll-way 115 feet long and 10 feet high; in the face are two arched openings with gates for drawing down the pond. The mills are able to run at full capacity by water about eight months in the year, and from two-thirds to three-quarters capacity the remainder of the time, during which they use steam in addition to water. The pondage above the dam is small, and water wastes at night nearly all the year. The large amount of water used at Southbridge reaches this privilege in the middle of the day, and, there being but small storage facilities here, continues to waste over the dam much of the night. It is thought that upon the completion of the new reservoir at Mechanicsville this water will be saved and the power at Putnam substantially increased. The experience with anchor-ice at this point is worth noticing. The Powhatan mill receives water from the pond directly into its flume, while the Putnam company often draws through an old race; the former mill suffers little or none from ice, but the latter is much hindered and requires considerable labor in clearing its race.

Slackwater from the privilege just described extends to a small place called Reedville, a short distance above the mouth of French river. Here Messrs. Sayles & Washburn, who already have a mill at the mouth of French river, on the latter stream, have recently constructed a dam which will pond a large surface of water, roughly

a Leased to the New York and New England railroad, and denominated by it the "Norwich division"

estimated at 450 acres; this privilege has been developed for their own use, and will probably be employed to furnish power to a new mill. The pond will be connected by a cross-cut with the pond above their dam on French river, and the two privileges can thus be operated so as to be of mutual assistance.

At the site of the new dam the river-bed is gravel, with some quicksand. The dam was carried down 3 or 4 feet below the surface of the apron into the river-bed, and protected by sheet-piling in the usual manner. The roll way is 200 feet long, rises 15 feet above the apron, is 4 feet wide on top, 30 feet wide at the base, and has front and back slopes of 20 feet each. The back slope is covered with 2½-inch, the top with 4-inch, and the face with 3-inch chestnut planking. In interior construction the dam is a log crib-work filled with stone. An apron projects 16 feet beyond the foot of the dam, and has a permanent covering of 4-inch chestnut plank, over which is a temporary layer of 2-inch white-oak plank, easily renewed when worn out. From the roll-way there extends a gravel embankment 900 feet long, about 20 feet high, 60 feet wide at the base and 24 feet at the top, the inner slope of which will be riprapped. At the farther end of the embankment is the bulkhead, with gates opening into the race.

Above the mouth of French river the Quinebaug has considerably less water than below, but still furnishes important powers, which are used at numerous points. I shall not describe them in detail, but more or less information regarding them may be obtained from the following table:

Utilized powers on the upper Quinebaug river.

[Reedville to Southbridge (in order, ascending the river).]

Locality (town).	Occupied by—	Fall.	Horse-power of wheels.	Remarks.
		Feet.		
New Boston, Connecticut	G. T. Murdock & Son	9½	100–110	Woolen goods, 5 sets of cards. Water nearly always wasting on dam.
Dudley, Massachusetts	E. S. Stevens	12	110	Manufactures gunny-cloth. Small power also used by a 1-run grist-mill. Stone dam; roll-way, 230 feet long; pondage, 40–45 acres. Mr. Stevens owns 6 feet of fall below his privilege.
West Dudley, Massachusetts	Warren Paper Mill	12¾	112	Small power also used by Wells' grist-mill. Perhaps 50 horse-power surplus for rental.
Saundersdale, Massachusetts	Southbridge Print Works	14½	285	
Southbridge, Massachusetts	Columbia Mills			Print-cloths. Not running.
Do	American Optical Works	7½	35	
Do	Central Mills Company	37	280	Cotton goods, 11,000 spindles. No lack of water; always waste over dam at night. Two falls of 15 and 22 feet, respectively.
Do	Hamilton Woolen Company	54	800	Manufactures cotton goods, cassimeres, and worsted dress goods. Steam used in addition to water. Privileges improved by stone dams, with gravel backing, and priming above and below. Power taken from three falls of 14, 26, and 14 feet, respectively. About 650 horse-power actually used.

Southbridge, at which, as may be seen from the table, several important concerns are located, is a beautiful village and of considerable size; it is built upon hilly ground, with fine streets, and with the usual advantages of a prosperous and established manufacturing village. It has but one railroad, and at times freights have been so high that the Hamilton Woolen Company shipped by team to Charlton, on the Boston and Albany railroad; at present, however, rates on staple articles, such as cotton and wool, are claimed to be as favorable as those enjoyed by Lawrence or Lowell.

The Hamilton company owns five reservoirs, supplying the river above Southbridge; they contain an aggregate area of over 900 acres, and usually fill. The Fiskdale Mills, situated above on the stream in the town of Sturbridge, also own three reservoirs, known as Big Alum, Little Alum, and Long ponds; these have a combined flowage of about 412 acres and a storage capacity of 200,000,000 cubic feet.

The country along the Quinebaug from Reedville to Southbridge is hilly and moderately timbered. There is in this distance unimproved fall belonging to the various farmers whose land adjoins the stream; no data could be obtained showing the total amount of this fall, but several privileges were learned of, as follows:

1. Immediately below E. S. Stevens' privilege (which is really situated just above the Massachusetts line, though the post-office is Quinebaug, Connecticut). That gentleman owns 6 feet of fall, and there is estimated to be several feet more thence to Murdock's privilege; altogether there may be 10 feet.

2. Between Stevens' privilege and that at West Dudley there is 18 feet 4 inches of unimproved fall; of this Mr. Stevens owns 8 feet, and holds it for future use in connection with his business, leaving say 10 feet available for other manufacturing.

3. Between West Dudley and Saundersdale there is 9 feet 7 inches of unimproved fall, owned by Mr. Charles Wells, of the former place. A dam could be built near the foot of this privilege, convenient to the railroad, and would flow about 9 acres.

4 and 5. At Southbridge the Hamilton Woolen Company owns two undeveloped falls, one of 13 and the other of 30 feet.

The power at these several privileges may be estimated as in the accompanying table:

Estimate of power at unimproved privileges between Reedville and Southbridge.

Locality.	Drainage area.	Fall.	Theoretical horse-power. (a) Low water, dry year.	Low water, average year.	Ten months, average year.
	Sq. miles.	*Feet.*			
Southbridge	100	30	150	170	200
		13	65	75	90
Between West Dudley and Saundersdale		9.6	60	70	90
Below West Dudley		10	70	75	95
Below E. S. Stevens' privilege	145	10	75	80	100

a Based on average flow for the twenty-four hours. The power could probably be doubled for twelve hours in low stages.

TRIBUTARIES OF THE QUINEBAUG RIVER.

Pachaug river.—This properly has its source in four small head-streams which unite a short distance above the village of Voluntown, in the southeastern corner of Windham county, Connecticut. The river then pursues an irregular course to the westward, passing across the town of Griswold, and joins the Quinebaug at Jewett City. It drains 59 square miles, and toward the mouth, where running freely, does not measure probably more than 50 feet across. The valley is wide, and though there are many steep slopes, yet in the vicinity of the Pachaug reservoir there is, on the whole, a gradual rise in nearly every direction to the summits of distant high hills. The country is moderately wooded, the proportion of timber increasing away from the Quinebaug and toward the summits of the hills. The covering of soil is thin, and rock ledges and drift bowlders crop out in all directions. There is comparatively little cultivation, and that chiefly in corn, potatoes, rye, oats, and buckwheat.

The powers, in order, ascending the stream, are as follows:

1. Near the mouth are John F. Slater's mills, running 20,000 spindles in the manufacture of denims, ticks, and other goods. The privilege embraces a total fall of 37½ feet, used in two falls of 15 and 22½ feet, respectively; 400 horse-power is employed at these mills, and a small grist-mill is also supplied by a side-cut from the upper fall.

2. The Ashland Cotton Company uses a fall of 18 feet 9 inches, and 275 horse-power. It has two mills, one an extremely large and fine structure, and runs about 25,000 spindles; during 1881 and 1882 it increased the capacity of its mills 30 per cent. The dam was built in 1858, and was recently raised a foot; it is 75 feet long, 19 feet high, and secures a pondage above of 100 acres.

3. At Hopeville, a couple of miles above the mouth, there is a dam giving 14 feet fall, and surveys have been made with reference to raising it 7 feet, and thus forming a pond extending back nearly to the foot of the Pachaug Reservoir dam. The Ashland company owns this privilege, and formerly had mills here, which were burned; it intends to erect new mills, however, and to use the power.

4. At Pachaug Reservoir dam there is a fall of 12 or 13 feet not in use. This, and in fact all the fall on the stream below, down to Slater's mills, belongs to the Ashland company, which also owns the adjoining land in that distance.

A summary may be given of the above and the remaining powers on this river, as in the following table:

Water-privileges on the Pachaug river (in order from the mouth.)

Occupied by—	Fall.	Horse-power utilized.	Remarks.
	Feet.		
John F. Slater	37½	400	Two falls, 15 and 22½ feet.
Ashland Cotton Company	18¾	275	
Do	21		Power not used. Dam gives 14 feet fall, but can be raised 7 feet. Located at Hopeville.
Do	12-13		Pachaug Reservoir dam. Power not used.
Glasgow Yarn Company	24		
L. W. Carroll	18½	175	Cotton prints.
Ira G. Briggs & Co	15	100	Briggs & Co. manufacture twilled cotton goods and yarns, and run a total of about 15,000 spindles at all the privileges.
Do	22	50	
Do	11	70	
Do	15	100	

Above Briggs & Co.'s upper dam there is a pond of 40 or 50 acres. There have been specified all the powers on the Pachaug up to this point. Everything is in use except at Hopeville and at Pachaug reservoir, and those privileges, being reserved by the Ashland company, are not open for general manufacturing. Above Voluntown,

on the small streams which have been alluded to as making up the main river, there are some small saw-mills, but the powers cannot be considered as having much value. The fall of these streams is said to be small, and even if reservoired as hereafter described, the reservoirs would be in their lower courses, leaving little fall below.

The most interesting feature of the Pachaug is its reservoir development. Although the stream has considerable fall, there are occasional wide stretches along its course of low marshy ground which have given opportunity for a large flowage. Aside from the regular mill-privileges, the principal of which have been mentioned, there are at the present the following reservoirs on the stream:

Pachaug reservoir is entirely artificial, and contains from 900 to 1,000 acres, according to the stage of water. It is formed by an embankment and dam having a combined length of about 600 feet. The overflow is 80 feet long, and is a framed timber structure, with a partial filling of loose stone, masonry abutments, and an apron. This reservoir can be drawn down 12½ feet, and gives a large storage; it is owned by the Ashland company.

Billings Pond reservoir, covering say 100 acres, lies among the hills, is fed almost entirely by springs, and empties by a small side stream into the upper part of Pachaug reservoir; it also is owned by the Ashland company. Mr. J. O. Sweet, superintendent of the company, who furnished much information regarding the Pachaug, mentions an interesting fact about this reservoir. He states that all evidence has shown that by maintaining it full its total yield is diminished, and explains it by supposing that when full the great pressure of the water forces the springs to seek outlets in some direction other than into the reservoir. The pond is therefore drawn down early in the season, and the gates are then left open, so that the natural flow of the stream goes on.

Beach pond, in the upper waters of one of the four head-streams, is estimated to contain from 1,000 to 1,200 acres, and is a natural lake which has been raised by a dam some 300 feet long, at the outlet. It is very deep, and though it can be drawn down 12 feet there then remains a depth of 50 feet in portions. This reservoir is controlled by Messrs. Ira G. Briggs & Co.

The effect of these large reservoirs is to render the stream very steady. Neither the Ashland nor Slater's mills have been forced to stop more than a day and a half in sixteen years from lack of water, but, as previously stated, the capacity of the former mills having recently been increased 30 per cent., there is some question as to whether they may not now run short at times. The river is also freed from the effects of heavy freshets. In the lower course there is a freshet depth on the Ashland dam of only about 18 inches, whereas, before the stream was so well reservoired, it amounted to many feet. About the year 1862 the dam at Beach pond gave way, and a large volume of water came pouring down stream; but striking into the marshes where the Pachaug reservoir now is, it spread out and caused no harm at Jewett City, neither was there much of a rise there.

The Ashland company practices great economy in the use of the stored water which it controls. It is connected by telephone with the house of the gate-keeper at Pachaug reservoir, and is thus enabled to regulate the flow very carefully. The gates are opened in the morning some hours before the time for starting the mills, in order that the water may have time to reach them, and are closed some hours before the mills shut down. The water is thus maintained just even with the top of the dam at Jewett City, without allowing waste over its crest.

Though the Pachaug is already so well reservoired, there is yet opportunity considerably to increase its capacity in this respect. Messrs. Ira G. Briggs & Co. state that shortly above their upper privilege at Voluntown, between it and Beach pond, there is a chance to flow 1,000 acres by a dam 10 feet high. On the remaining three streams which go to make up the Pachaug at this point, storage reservoirs of fair size can be constructed on their lower courses, the land being rather low and marshy. On one of these streams a survey has shown that a dam 20 feet high would flow 150 acres to an average depth of 10½ feet, and Mr. Briggs is of opinion that about the same flowage would be obtained on the other two. The dam at Hopeville, also, if raised 7 feet, would give a largely increased storage there.

Moosup river.—This stream has its source in the town of Foster, Rhode Island, 2 or 3 miles east of the Connecticut boundary. It runs southerly and then westerly, passing through the towns of Foster and Coventry, Rhode Island, and the towns of Sterling and Plainfield, Connecticut; its total length is about 18 miles, and its drainage area 83 square miles. Its valley is not unlike that of the Pachaug, but perhaps shows less outcropping rock. The hills are high and frequently steep, but they appear, as a rule, to have long slopes. The country has little value for agriculture, and has been mainly cleared of timber, except toward the summits of the high hills or away from the more immediate valley of the Quinebaug. The soil is described as rather shallow, but underlaid nearly everywhere by clay, so that water is easily obtained in wells both on the hills and in the valleys. The water-shed is quite extensive, and the hill-slopes are sufficiently inclined so that water from rains drains rapidly into the stream and raises it, after which it quickly subsides. The greatest height is usually reached about twelve hours after a storm, the freshet rise in the lower course amounting to about 6 feet below the dams. No difficulty is experienced on this river from anchor-ice; cake-ice sometimes piles up on the flats, and even to some extent chokes up the stream, but no serious trouble ensues. In its lower course the Moosup is from 75 to 100 feet wide. Its bed is mainly drift, gravel, and small bowlders. The banks are irregular and poorly defined, sometimes rising abruptly from the stream, and again low, with a gradual ascent.

The principal reservoir supplying this stream is Moosup pond, a natural lake raised by a low embankment. It lies immediately surrounded by hills of moderate height, and empties by a small outlet into Snake Meadow brook,

and thence into the Moosup; it is distant a half or three-quarters of a mile, in a direct line, from the latter stream, and is a fine reservoir. The surface is estimated at 600 or 700 acres, which is perhaps too high, and the pond can be drawn down 6½ feet. Messrs. Aldrich & Milner control this reservoir, but if they have occasion to shut down their mill on the Moosup they are under obligations, for the benefit of the Aldrich & Gray mill below, so to manage the reservoir as to maintain the same flow as before.

Above the stone dam at Almyville there is a pond estimated to contain 100 acres, and at Oneco one of 125 acres; these are at privileges available for manufacturing, but not in use, and at present serve only for storage.

The amount of storage on the stream can yet be very largely increased. Aldrich & Milner intend to raise the stone dam at their reservoir (Almyville), and will thereby increase its flowage, as they estimate, by 250 or 300 acres. Thence to Greene the valley is regarded as favorable for storage, and toward the headwaters, in Rhode Island, the facilities are still better; there is much low land in that section, having little value, which might easily be flowed. The amount of storage thus available in that locality is variously stated at from 1,000 to 3,000 acres, but is large at all events.

There have been numerous changes in the firms manufacturing on this river, and many of the present concerns are new-comers. The mills are of fair size, and are in many cases built of stone, which is claimed to be cheaper here than brick for building. Nearly all have engines for use in low water. The stream is said to have decreased in value of late years. The only explanation given of this was, that a number of small privileges on the upper course, previously used for saw and other small mills, had been abandoned; these had formerly stored considerable water above their dams, but the latter had gone to ruin, and, the storage being lost, the stream became more unsteady.

Water-privileges in use on the Moosup river (in order from the mouth).

Occupied by—	Fall.	Horse-power utilized.	Remarks.
	Feet.		
....	9	100 (?)	Henry Cutler owns one-half the privilege and E. N. Tourtelotte one-half. Log dam, 120 feet long. Power used by several small establishments, comprising a wick-mill, twine-mill, grist-mill, saw-mill, and carpenter's shop.
....	4	35 (?)	Log dam, about 100 feet long. Power owned by J. P. Kingsley, of Canterbury, and leased to a small grist-mill and carriage-shop.
Kirk Mills	14	125	Plain cotton goods. Old and cheap log dam. Short of water three or four weeks in some years.
Do	9½	90	Fancy cotton goods.
Aldrich & Gray	21	200	Print-goods; 9,000 spindles.
Floyd Kransky	12	50	Thread-mill.
Aldrich & Milner	21	200	Fancy cassimeres; 12 sets of cards.

These mills all lie between the mouth and Almyville, a distance of 4 or 5 miles. Above, at Sterling, there is a small mill manufacturing colored umbrella cloth and cotton goods; there are also said to be a few saw-mills above Oneco, but no important powers are in operation.

There are several falls on the stream not in use. The lowest of these in order is below Canada City, near the mouth, amounts to 9 feet, and is owned by Mr. Henry Tripp, of Central Village. Judging from the powers at the other mills, this privilege should be reliable for 80 effective horse-power ten months in the year.

Immediately below their mill Messrs. Aldrich & Gray own 17 feet of unimproved fall, equivalent, on the same basis as above, to about 150 horse-power.

At the Almyville stone dam, Messrs. Aldrich, Milner & Gray hold for sale a fine unoccupied privilege. It is close beside the Providence division of the New York and New England railroad, which follows up the valley of the Moosup river nearly to Greene, Rhode Island, and has good building stone and sand close at hand. The dam is of horseshoe shape, 18 feet high, and constructed of stone; the face descends by a series of offsets, or steps. On the right bank the dam abuts against a rock ledge; on the left it is supplemented by a short embankment faced on the sides with stone. It was reported that within a year, during a freshet, water had forced its way across the shore end of this embankment, but that prompt action had prevented serious harm being done. Above the dam is a long narrow pond estimated to contain 100 acres; the owners design raising the dam 3 or 4 feet, and thereby increasing the flowage by 250 or 300 acres.

At Oneco, in the eastern part of the town of Sterling, there is a good privilege, formerly occupied by the Oneco Manufacturing Company, cotton goods, using 18 feet head and 100 horse-power. The dam is of wood, 100 feet long and 12 feet high, and creates a pond of 125 acres.

Five-Mile river rises in the town of Douglas, Massachusetts, runs southerly through the towns of Thompson, Putnam, and Killingly, Connecticut, and empties into the Quinebaug at Danielsonville. Its length by general course is about 19 miles, and its drainage area 77 square miles. Its principal branch is Whitestone—also called Whetstone—brook, which will be separately described.

The valley of Five-Mile river is in general rather wide and flat. The stream itself is 30 or 40 feet wide in its lower course, and runs over a bed covered with stones. It is supplied from reservoirs and has a very steady flow; there are no freshets in it of consequence, it is free from anchor-ice, and surface-ice never goes over the

dams, but melts away in the ponds. This stream has been developed to about its full capacity. With one exception, no available unimproved fall below Quaddick reservoir could be learned of, and it is also claimed that the reservoir storage cannot be further increased unless at unreasonably heavy expense.

There are now three principal storage reservoirs in this basin. Wakefield pond lies in the eastern part of the town of Thompson and drains into Quaddick pond, which is immediately below it; the two are estimated to cover 1,500 acres. Quaddick pond can be drawn down 11 feet. Both are natural lakes raised by dams. They are owned, three-quarters by the Attawaugan Company and one-quarter by Sabin L. Sayles. They are filled mainly by the melting snows and rains of spring, and the mills commonly begin to draw upon them in July. Keach's reservoir is of good size, but its area could not be ascertained. It empties by a side stream between Quaddick pond and the Attawaugan Company's upper privilege, and is owned jointly by several of the mills.

Water-privileges on Five-Mile river below Quaddick reservoir (in order from the mouth).

Occupied by—	Fall.	Horse-power utilized.	Remarks.
	Feet.		
Quinebaug grist-mill	12	50–75	Has no separate dam. Obtains 5 feet fall from the tail-race of the Danielsonville Cotton Company, and 7 feet at the Quinebaug Company's dam adjacent on the Quinebaug.
Danielsonville Cotton Company	24½	360	Manufactures cotton sheetings; 17,000 spindles. Stone dam about 110 feet long. Can store the night-flow of the stream about half the year.
S. L. Sayles & Co	19	200	Located at Dayville. Manufacture fancy cassimeres. Ordinarily have sufficient water throughout the year.
	8–10		Small saw-mill.
Attawaugan Company (*a*)	30	236	Stone dam 25 feet high, 120 feet long.
Do	20	220	Stone dam; 20-acre pond.
Do	12		Do.
	24		Owned by Sabin L. Sayles, but unoccupied. Has a good stone dam and long narrow pond, and is less than half a mile from the Attawaugan Company's upper privilege.
	12	40	In use by twine-mill at outlet of Quaddick reservoir.

a This company manufactures plain cotton goods. One mill weaves, and the other two mills have together 37,000 spindles.

Whitestone brook is a little stream, not over 4 miles long measuring from the reservoir at its head. It runs westerly across the town of Killingly, and drains 19 square miles. The bed is gravelly and rocky; the fall is slight in the middle course, but large toward the mouth, and especially so in the upper waters, where the valley is narrow and hemmed in by high hills. The dams are short and usually built of stone. In the summer of 1882 eleven privileges were in use, the manufacturing at which was confined to cotton goods and fancy cassimeres. The falls were large, ranging in several cases from 20 to 40 feet; there was also one fall of 14 feet occupied by a cotton-mill not running; and one of 38 feet, near the head of the stream, entirely unimproved.

This brook is considered a fair milling stream. Its flow is well sustained, but is not sufficient to carry the mills through the year, and nearly or quite all of them use steam in low water. The reservoirs are all at the head of the stream, and are as follows: Old Killingly pond, the largest, is a natural lake raised by a dam. When drawn down all that is practicable, 15 feet below full-water line, a large amount of water still remains in the natural basin. The pond is fed by springs, but receives very few brooks; it partially fills in spring from rains and melting snows, but has not been full in ten years. If full, this pond alone, it is said, would carry the mills on the brook for three months. It is practicable, and the plan has been discussed, to drain the surplus waters of the upper course of Five-Mile river into this pond. No injury would be done to that river, the reservoir would be filled, and the power of Whitestone brook very much increased.

There are four other reservoirs, known as Edy, Simmons, Middle, and Bog Meadow; they can be drawn down from 8 to 12 feet each, and flow an aggregate area estimated at 255 acres. They are entirely artificial, and have been built at considerable expense.

All of the five reservoirs which have been mentioned drain into a pond just above Ross' mill, the highest on the stream and located nearly at the top of Chestnut hill. They all, with the exception of Old Killingly pond, fill regularly in spring, and the mills commonly begin to draw upon them in May. All are owned by a reservoir company, in which most of the mill-owners on the stream are shareholders.

French river.—This stream, the most important tributary of the Quinebaug, rises in the towns of Leicester and Spencer, Worcester county, Massachusetts. It flows southerly, with an extreme length of 25 or 30 miles, and joins the main river in the town of Thompson, Connecticut. Its drainage basin includes 115 square miles. In the upper waters are numerous artificial storage reservoirs, of which the principal ones are as follows:

1. Chaubunagungamaug lake is a splendid sheet of water lying east of the village of Webster. It has a very irregular outline, measuring 17 miles in circuit, contains 1,300 acres, drains 9 square miles, and can be drawn down 4 feet from full-water line. The aggregate draught upon it in an average year is estimated equivalent to a depth of 10 or 11 feet. This lake is supplied by many springs, and also has three brook feeders.

2. Robinson pond lies in the towns of Oxford and Sutton, and drains into French river some 4 miles above Webster. It is artificial, contains 100 acres, can be drawn down 4 feet, and is controlled by a small mill on the outlet.

3. Sacarap reservoir is artificial, and lies in the town of Oxford. It contains 125 acres, is 27 or 28 feet deep, and can be drawn down the whole depth. It is used for storage purposes alone, and there is rarely any waste of water at the outlet.

4. Charlton or Granite reservoir, artificial, is controlled by Messrs. Buffum and H. N. Slater. It contains 240 acres, will fill twice in the year, or the equivalent of once to an average depth of 16 feet, and drains 7 square miles.

5. Pierpont Meadow pond, in the northern part of the town of Dudley, is artificial, flows 100 acres, and averages say 5 feet in depth.

6. Platte pond, in Charlton and Oxford, is artificial. Its water-shed embraces 11 square miles, with steep and impervious drainage slopes. This reservoir is 17 feet deep, covers 125 acres, and fills many times in the course of a year.

7. Burncoat pond, in the town of Leicester, 142 acres, can be drawn down 12½ feet from the top of the roll-way. It is owned by the Rochdale Mills.

8. Cedar Meadow pond, in the southwestern part of the town of Leicester, flows 153 acres, and can be drawn down 11 feet. It is owned by the Rochdale Mills. Both Burncoat and Cedar Meadow ponds fill regularly in spring, and the water can be drawn quite thoroughly from their basins. The average depth for their entire surface is probably not more than 6 or 7 feet.

9. Styles' reservoir, artificial, is controlled by an association of mill-owners. It is 26 or 27 feet deep, flows 400 acres, and drains an area of 7 square miles.

Except as stated otherwise, the above reservoirs are owned by the Messrs. Slater, of Webster. In addition to these sources of supply for French river, the Stevens Linen Works, of Webster, control 279 acres of storage, comprised in a series of five reservoirs lying westerly from the village.

In the lower part of its course French river is perhaps 50 feet wide where running freely, with a good current, and shoals at intervals. There is but a small portion of its course below Webster, however, that is not controlled by dams. But one unimproved privilege in that distance was reported; it lies between Mechanicsville and Grosvenordale, includes 15 feet fall, and is owned and held for its own use by the Grosvenordale Company. In this section the immediate valley of the stream is rather narrow, though it widens out occasionally and incloses meadows, through which the river flows between banks from 5 to 8 feet high. The bed of the stream is generally gravel, and its waters are clear and of good quality; they have no injurious action upon iron surfaces, but, if allowed to stand, show a kind of gelatinous deposit which is supposed to be due to vegetable matter.

Power is used on the lower course of this stream as shown in the following table:

Water-privileges on French river below the village of Webster (in order from the mouth).

Locality.	Occupied by—	Fall.	Horse-power utilized.	Remarks.
		Feet.		
Mechanicsville	Sayles & Washburn	15	200	Pondage estimated at 50 acres. Can run full capacity by water all but one or two days in the year. There is always a surplus when the Grosvenordale mill is running. No trouble from backwater or ice. Manufacture fancy cassimeres.
Mechanicsville–Grosvenordale.	Grosvenordale Company	15	....	Fall unimproved and held for company's own use.
Grosvenordale	do (*a*)	12	180	Cotton goods; 20,000 spindles. Stone dam; roll-way 116 feet long.
Do	do (*a*)	12	180	Cotton goods; 11,000 spindles—harder driving than previous mill. Stone dam.
North Grosvenordale	do	26½	400	Two splendid brick mills for the manufacture of cotton goods; 65,000 spindles. Stone dam; roll-way 104 feet long, with a spill-way of equal length for high water. Pond of 80 acres, which serves as reservoir for the three privileges. Can realize 400 horse-power from water practically all the time; 300 horse-power or more of steam also in use.
Wilson's station	O. F. Chase	12	45–50	Manufactures cassimeres.
Perry's station	Dudley Woolen Mills, Josiah Perry proprietor.	10	75	Fancy cassimeres; 6 sets of cards. Curving stone dam.
Below the village of Webster.	John Chase & Sons	10½	....	Fancy cassimeres. The pondage at these upper privileges is small, and the mills are dependent upon the running of those at Webster.

a Both mills can run at full capacity by water all the year. No hinderance from backwater or ice. Small ponds here, but at North Grosvenordale there is a large pond which for five months in the year controls the flow of the stream.

Webster is a large manufacturing village, with extensive mills, using power from three different streams. On the main French river, at what is known as the South village, the Messrs. Slater (Slater Woolen Company) manufacture woolen goods, using 17 feet fall, 315 horse-power of water, and say 175 of steam. At the North village, also on French river, they manufacture cotton goods, employing 18 feet fall, and an average of 200 horse-power of water and 350 of steam.

At the East village, on the outlet of lake Chaubunagungamaug, the same company has dyeing and finishing works, with from 24 to 28 feet fall and utilizing 100 horse-power, which can always be realized from the supply furnished by the lake.

The Stevens Linen Works are located upon a small stream supplied by five reservoirs, previously mentioned. These have a combined flowage of 279 acres, and are in the main artificial, only one having been a natural pond. They generally fill in the spring, but are soon drawn down, and furnish enough water for running the various wheels at full capacity only about three months in the year. Steam is used at the bleachery a part of the time, and at the main mill constantly. At the former a 75 horse-power turbine is run under 12 feet head. At the main mill there are two falls. The upper has a 40-foot breast-wheel, with buckets 15 feet wide, and is estimated at 150 horse-power; the lower has a 20-foot breast-wheel, with buckets 15 feet wide, and is roughly estimated at 50 horse-power. The Stevens Linen Works manufacture linen towelings, employ 400 hands, and use 800 tons of stock per year. The principal mill is a handsome structure of stone, 200 by 70 feet in plan, five stories high, and with two large L's.

Passing above Webster, French river continues to be used at short intervals for power, but its size is reduced and the mills are comparatively small.

MINOR TRIBUTARIES OF THE QUINEBAUG.

Mashamoquet brook runs southerly and then southeasterly through the town of Pomfret, Connecticut, joining the Quinebaug a mile or so above Williamsville. It drains 30 square miles, and is used for power by several small saw- and grist-mills. At Pomfret Landing, Binn's 2-run grist mill has 20 feet fall, 55 horse-power of wheels, and is short of water during July and August. The brook is about 40 feet wide between banks in its lower course, has a rapid descent, and is very unsteady, coming up and falling again quickly after rains. The common freshet-rise at Pomfret Landing, which is near the mouth, is about 6 feet, but after a heavy winter or spring rain a rise of 15 feet has been known, widely overflowing the valley.

There is undeveloped fall on the stream, and opportunities exist for considerable storage. The people living near are said to be anxious to have the power improved, and to be willing to assist in any enterprise looking to that end. Six miles above Pomfret Landing, at what is known as the Nightingale privilege, it is claimed that, by building a dam 250 feet long, 20 feet of water could be stored, flowing a surface of 600 acres. This privilege is said to be owned by Mr. Joshua Angell, living near by. It was reported, also, that at a point 2 miles above Pomfret Landing there is an unoccupied privilege, with dam already built, where by putting in gates a considerable flowage can be commanded.

For ten months in an average year a discharge from this stream at its mouth of from 12 to 15 cubic feet per second can probably be relied upon under the present conditions.

Alexander's pond contains, by map measurement, 216 acres. It lies a little way east of the Quinebaug and north of Williamsville. In winter Five-Mile river sends its surplus waters into this pond, but its only outlet is by a small stream emptying just below the Williamsville mill. It can be drawn down 4½ feet, and furnishes power most of the year to O. S. Arnold's bobbin-shop, using 32 feet fall and 35 horse-power.

Little river, or *Muddy brook*, comes down through the town of Woodstock, Connecticut, and empties into the Quinebaug near Putnam. It is stated to have a rapid fall and to be used for power at several points by small twine- and cotton-mills. For 1 mile above the mouth the fall on this stream, including two privileges of 16 feet each, is owned by Mr. George Morse, of Putnam. Immediately above there was formerly a weaving-mill using 18 or 19 feet fall; Woodstock pond, measuring 86 acres on an old state map, but represented to me as now flowing over 200 acres, serves as a reservoir for this privilege.

THE YANTIC RIVER.

Formed by small streams rising in the towns of Lebanon and Colchester, Connecticut, the Yantic flows southeasterly, and at Norwich joins the Shetucket to make up the Thames. It drains an area of 96 square miles, composed of a hilly country, well timbered away from the immediate valley and especially in the upper waters. This district is well supplied with springs, and the river also receives aid from several reservoirs; nevertheless its volume sinks quite low in the dry season, and the mills generally rely upon steam for assistance then. The Yantic rises rapidly after heavy rains, and is described as an "angry little stream" at such times. Considerable running ice passes down its course on the breaking up of winter, and slight hinderances are suffered at times from anchor-ice and backwater; trouble from these causes is not sufficient, though, to cause any stoppage of the mills, except in rare instances. The stream is quite variable in width, but in the lower course, where running freely, does not usually measure more than 50 or 75 feet across.

Of the reservoirs, Gardner's lake, situated on the boundary between the towns of Salem, Montville, and Bozrah, is the largest. It flows 816 acres, and drains an estimated surface of 3,268 acres; it is a natural pond raised by an embankment, can be drawn down 7 feet, and fills regularly. This reservoir is owned by the Falls Company, of Norwich.

The Bozrahville Company controls two reservoirs in the western part of the town of Lebanon. Neither their names nor size could be learned with certainty, but they are probably the sheets of water represented on the maps as Williams and Kent ponds. By measurement upon a county map of 1868, Williams pond contains 330 acres, and Kent pond 83 acres; the latter lies below Williams pond, a short outlet joining them.

The Hayward Rubber Company owns a reservoir in the southern part of the town of Lebanon, known as Cedar Swamp reservoir; it is fed mainly by springs, covers 145 acres, and can be drawn down 10 feet.

It is stated that the country drained by the Yantic is very favorable to the construction of reservoirs, and that the capacity in that respect might be materially increased. There are several small streams, of which Deep brook is one, that would furnish a good supply of water and might be thus improved.

In the 9 miles from Bozrahville to the mouth, including the more important part of the river's course, the fall is almost entirely taken up. It appears to be mainly concentrated in two sections. From a mile above Bozrahville down to Fitchville it is rapid, amounting to 104 feet at four privileges.* For 3 miles above the upper end of this section the fall is slight; it is also slight below it to the vicinity of the mouth, amounting to only 30 feet at three privileges, but at Norwich the descent is again large.

Principal water-privileges on the Yantic river (in order from the mouth).

Locality.	Occupied by—	Fall.	Horse-power utilized.	Remarks.
		Feet.		
Norwich	Falls Company	53	850	Manufactures tickings and cheviots; 20,000 spindles. The river here falls precipitously through a narrow rocky gorge, at the head of which is a curved stone dam from 160 to 170 feet long. Water is carried from the pond in a race and used in two levels. At the upper level 28 feet fall and about 450 horse power are used; at the lower level 25 feet fall and 400 horse-power. *These amounts can be realized about nine months in the year; the rest of the time the supply of water is deficient. Tide-water sets back to this privilege, and rises about 3 feet on the wheels.
Do	Falls Company (upper privilege)	17	....	Power leased by Falls Company to Norwich Pistol Company and Allen Spool Company, using, respectively, 15 and 17 feet fall from a common race. Pond large, but shallow. Stone dam, 21 feet high, 20 feet wide at base, inclined coping stones, 7 feet long; face of dam batters 4½ inches to 1 foot.
Norwich Town	Norwich Woolen Company	7	100	Manufactures blankets and repellents; 12 sets of cards.
Bean Hill	Clinton Mills Company	9	85	Repellents; 11 sets of cards. Stone and wood dam. Can run from seven to ten months at full capacity by water, but uses steam in low water.
Yantic	Yantic Woolen Company	14	....	Manufactures flannels; 10 sets of cards. Uses two 42-inch Swain and one 36-inch Hunt wheels. Can run full capacity nine months by water, and estimates that power never falls below 50 horse-power. Framed dam, 70 feet roll-way. Small pond.
Fitchville	Fitchville Manufacturing Company.	24	300	Cotton goods; 13,000 spindles. Receives the benefit of Gardner's Lake outlet, which empties shortly above here. Pondage about 90 acres above dam. Latter is a stone and timber structure, 95 feet roll-way. In low water of August, 1882, about three-quarters of the capacity of the wheels was being realized. Can usually run nine or ten months in the year at full capacity; in the dry season of 1881 the supply in the reservoirs failed, and for a time there was no water here worth mentioning.
....	Bailey	....	....	Saw-mill.
Bozrahville	Bozrahville Company	20	....	Privilege unoccupied, but held for company's use. Already improved in part by a dam giving from 10 to 12 feet fall.
Do	......do	30	125	Manufactures cotton goods; 7,000 spindles. Can commonly run eleven months in the year at full capacity, but uses steam in low water. River is rocky here, and dam rests on natural ledge. Small pondage at dam, but company controls two reservoirs previously described, the larger of which will maintain the supply at this privilege six weeks under ordinary circumstances, and the smaller two weeks.
Do	Hayward Rubber Company	30	175	Grinding-mill.

Above the Hayward company is the Yantic Paper Company, and there are possibly one or two saw- and grist-mills still higher up stream. There is fall at the various reservoir outlets which is said to be used, in some cases at least, by small saw- and grist-mills; but being regularly drawn down, the reservoirs can furnish power for only a part of the year, and the amount on any one outlet would be small.

Utilized power on tributaries of the Thames river.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Thames river	Long Island sound	Connecticut	New London						
Shetucket river	Thames	do	do	Cotton	1				
Do	do	do	do	Bleaching and calendering works.	1	14½–17	1,600–1,700	700	Norwich.
Do	do	do	do	Paper	2				
Do	do	do	do	Flour and grist	1				
Do	do	do	do	Cotton	3	61	2,580	250	
Sundry small tributaries	Shetucket	do	do	Woolen	3	63	265	150	
Do	do	do	do	Worsted	1	28	10	40	
Do	do	do	do	Pulp	1	12	75	......	
Do	do	do	do	Paper	1	21	104	......	
Do	do	do	do	Fire-arms	1	40	10	10	
Do	do	do	do	Furniture	1	18	18	......	
Do	do	do	do	Saw	3	44	34	......	
Do	do	do	do	Flour and grist	1	12	50	......	
Do	do	do	Windham	Woolen	2	24	143	......	
Do	do	do	do	Paper	1	14	63	......	
Do	do	do	do	Cooperage	1	10	30	20	
Do	do	do	do	Fertilizers	1	26	15	......	
Do	do	do	do	Flour and grist	5	82	97	30	
Do	do	do	do	Saw	4	56	110	......	
Do	do	do	do	Machinery	1	55	80	......	
Do	do	do	do	Wooden types	1	30	35	......	
Willimantic river and tributaries	do	do	do	Cotton	5	87½	1,750	850	Willimantic. The Linen company has three mills here included, while a fourth is operated by steam alone.
Do	do	do	do	Sashes, doors, and blinds; wood turning and carving.	1	....	....	......	Rents power from Linen company.
Do	do	do	Tolland	Cotton	6	123	418	275	
Do	do	do	do	Woolen	13	305	744	460	
Do	do	do	do	Shoddy	3	44	15+	......	
Do	do	do	do	Upholstering materials.	1	26	15	......	
Do	do	do	do	Worsted	1	25	100	75	
Do	do	do	do	Hosiery	1	10	30	15	
Do	do	do	do	Silk	3	34	21+	......	
Do	do	do	do	Flour and grist	7	146½	155	......	
Do	do	do	do	Saw	12	143+	226	......	
Do	do	do	do	Ammunition	1	7	10	......	
Do	do	do	do	Blacksmithing	3	39	20	......	
Do	do	do	do	Boot and shoe findings.	1	40	12	......	
Do	do	do	do	Machinery	3	36+	50	15	
Do	do	do	do	Wood turning and carving.	1	36	40	......	
Do	do	do	do	Wheelwrighting	1	....	2	......	
Do	do	do	do	Carriage spokes	1	14	....		
Do	do	do	do	Wool extract	1	18	....	......	
Do	do	do	do	Wooden packing-boxes	2	15	52	......	
Do	do	do	do	Fire-arms	1	29	6	......	
Do	do	do	do	Musical instruments, organs.	1	10	35	......	
Do	do	do	do	Tools	1	7	4	......	
Natchaug river and tributaries	do	do	Windham	Cotton	2	22	75	......	
Do	do	do	do	Woolen	2	30	38	......	
Do	do	do	do	Silk	1	20	20	......	
Do	do	do	do	Flour and grist	8	95	179	......	
Do	do	do	do	Saw	13	154+	229	5	
Do	do	do	do	Paper	1	22	180	......	
Do	do	do	do	Wood-pulp	1	17	75	......	
Do	do	do	do	Agricultural implements.	1	10	33	......	
Do	do	do	do	Carriages and wagons	1	16	50	25	
Do	do	do	do	Wheelwrighting	2	27	16	......	
Do	do	do	do	Wood turning and carving.	2	17	23	......	

Utilized power on tributaries of the Thames river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Natchaug river and tributaries	Shetucket	Connecticut	Windham	Fertilizers	1	10	24	.....	
Do	...do	...do	...do	Cordage and twine	1	11	15	.....	
Do	...do	...do	...do	Tin, copper, etc	1	11	65	.....	
Do	...do	...do	Tolland	Cotton	1	14	60	.....	
Do	...do	...do	...do	Woolen	1	20	50	50	
Do	...do	...do	...do	Silk	6	63+	102	22	
Do	...do	...do	...do	Saw	4	63	57	.....	
Do	...do	...do	...do	Wooden packing-boxes	1	12	12	.....	
Do	...do	...do	...do	Blacksmithing	1	10	4	.....	
Do	...do	...do	...do	Wheelwrighting	1	5	5	.....	
Quinebaug river	...do	...do	Windham	Cotton	8	112	3,440	1,035	
Do	...do	...do	...do	Woolen	1	....	340	.....	Fall included above.
Do	...do	...do	...do	...do	1	9½	100	.....	
Do	...do	Massachusetts	Worcester	Cotton	5	89	1,110	.....	Three mills at Southbridge and two in Sturbridge.
Do	...do	...do	...do	Print works	1	14½	285	.....	
Do	...do	...do	...do	Woolen	2	40	475	.....	Southbridge.
Do	...do	...do	...do	Bagging, etc	1	12	138	.....	
Do	...do	...do	...do	Flour and grist	1				
Do	...do	...do	...do	...do	2	22	60	.....	
Do	...do	...do	...do	...do	1	13	152	.....	
Do	...do	...do	...do	Paper	1				
Do	...do	...do	...do	Spectacles and eye-glasses.	1	7½	35	.....	
Do	...do	...do	...do	Cutlery and edge-tools	1	12	81	.....	
Do	...do	...do	...do	Saw	1	7	40	.....	
Do	...do	...do	...do	Machinery	1	6	25	.....	
Do	...do	...do	...do	Marble and stone work	1	9	20	.....	
Do	...do	...do	...do	Carriage and wagon materials.	1	9	20	.....	
Do	...do	...do	Hampden	Flour and grist	2	20	52	.....	
Do	...do	...do	...do	Saw	2	16	81	.....	
French river and tributaries	Quinebaug	Connecticut	Windham	Cotton	4	50	760	450	Grosvenordale Company.
Do	...do	...do	...do	Woolen	2	27	250	.....	
Do	...do	Massachusetts	Worcester	Cotton	5	84	461	300	
Do	...do	...do	...do	Woolen	10	157	1,265	175	
Do	...do	...do	...do	Shoddy	2	12+	105	30	
Do	...do	...do	...do	Linen	1	72	275	(?)	
Do	...do	...do	...do	Flour and grist	6	98	158	.....	
Do	...do	...do	...do	Saw	6	88	128	.....	
Do	...do	...do	...do	Wooden packing-boxes	4	43+	60	.....	
Do	...do	...do	...do	Wire	1	17	20	15	
Do	...do	...do	...do	Cutlery and edge-tools	3	32	103	.....	
All other tributaries	...do	Connecticut	New London	Cotton	4	75	868	.....	
Do	...do	...do	...do	Woolen	1				
Do	...do	...do	...do	Flour and grist	1				
Do	...do	...do	Tolland	Saw	2	34	49	.....	
Do	...do	...do	Windham	Cotton	29	625	2,648	1,106	
Do	...do	...do	...do	Woolen	3	70	331	300	
Do	...do	...do	...do	Twine, etc	1	9	100	.....	
Do	...do	...do	...do	Upholstering materials.	1	12	60	.....	
Do	...do	...do	...do	Flour and grist	18	272	640	40	
Do	...do	...do	...do	Saw	27	311+	692+	.....	
Do	...do	...do	...do	Sashes, doors, and blinds.	1	8	8	.....	
Do	...do	...do	...do	Wheelwrighting	3	30+	59	.....	
Do	...do	...do	...do	Carriages and wagons	1	4	35	.....	
Do	...do	...do	...do	Machinery	3	15+	20	.....	
Do	...do	...do	...do	Saddlery hardware	1	....	5	.....	
Do	...do	...do	...do	Fertilizers	1	13	32	.....	
Do	...do	...do	...do	Drugs and chemicals	2	20	20	.....	
Do	...do	Rhode Island	Providence	Saw	2	39	37	.....	
Do	...do	...do	Kent	...do	3	47	88	.....	
Do	...do	Massachusetts	Worcester	Woolen	2	31	53	55	
Do	...do	...do	...do	Bagging, etc	1	12	360	300	

Utilized power on tributaries of the Thames river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
All other tributaries	Quinebaug	Massachusetts	Worcester	Buttons	1	7½	8	......	
Do	...do	...do	...do	Spectacles and eye-glasses.	1	9	5	......	
Do	...do	...do	...do	Flour and grist	2	29	40	......	
Do	...do	...do	...do	Saw	5	38+	87	......	
Do	...do	...do	...do	Sashes, doors, and blinds.	1	12½	25	......	
Do	...do	...do	...do	Cutlery and edge-tools.	3	15+	11	......	
Do	...do	...do	Hampden	Woolen	3	....	115	150	
Do	...do	...do	...do	Saw	2	21	36	......	
Do	...do	...do	...do	Brick- and tile-works	1	42	45	......	
Yantic river	Thames	Connecticut	New London	Cotton	3	107	1,275	400	
Do	...do	...do	...do	Woolen	3	30	315	210	
Do	...do	...do	...do	Vulcanized rubber	1	30	175	......	
Do	...do	...do	...do	Paper	1	24	105	......	
Do	...do	...do	...do	Flour, grist, and saw	1	9	60	......	
Do	...do	...do	...do	Fire-arms	1	} 17	95	......	
Do	...do	...do	...do	Spools	1				
Tributaries	Yantic	...do	...do	Flour and grist	2	28	34	......	
Do	...do	...do	...do	Saw	5	50	112	......	
Do	...do	...do	...do	Wheelwrighting	1	7	9	......	
Sundry small tributaries	Thames	...do	...do	Cotton	6	139	480	245	
Do	...do	...do	...do	Woolen	7	121	275	70	
Do	...do	...do	...do	Paper	6	129	280	60	
Do	...do	...do	...do	Dye woods, dye-stuffs, and extracts.	1	14	50	40	
Do	...do	...do	...do	Flour and grist	10	208	224	......	
Do	...do	...do	...do	Saw	8	117	151	......	
Do	...do	...do	...do	Wheelwrighting	1	7	5	......	

II.—THE CONNECTICUT RIVER AND TRIBUTARIES.

THE CONNECTICUT RIVER.

This stream, the most important one reaching Long Island sound, rises in the Connecticut lakes, in the extreme northern part of New Hampshire. It flows in a general southerly direction, forms the boundary between New Hampshire and Vermont, and, passing across the states of Massachusetts and Connecticut, empties toward the eastern end of the sound. Its length by general course is about 300 miles; following the windings as closely as possible on state maps, the length measures about 375 miles, and probably this is somewhat under the true distance. The drainage basin includes 10,924 square miles. In shape it is long and narrow, ranging from 40 to 50 miles in width in the upper course, and not much exceeding 60 miles in Massachusetts, where it is widest. In the north the section drained by the river is hemmed in by the White mountains of New Hampshire and the Green mountains of Vermont; to the southward, through Massachusetts and Connecticut, the water-shed lines are continued by ranges of high rocky hills. The character of the country thus included has been sufficiently described in the general remarks upon this part of New England. The impermeable rock which underlies the surface, the sands, gravels, and clays of the drift soil, all favor the formation of springs, which, together with numerous lakes and storage reservoirs, render the various minor streams, and in consequence the main river, steady and well sustained in droughts.

For the first 200 miles from its source the river contains numerous shoals and rapids and occasional abrupt pitches; but below Bellows Falls the general descent becomes much slower, and is broken by falls or important rapids at only three points—Turner's Falls and Holyoke, Massachusetts, and above Windsor Locks, Connecticut. At many localities along the upper course the high hills which inclose the valley approach close to the stream, and give rise to scenery which is beautiful though rather rugged; farther south, and especially in the vicinity of

Northampton, Massachusetts, the scenery is rendered less rugged, but none the less attractive, by extensive and fertile meadows. These mainly disappear near Middletown, Connecticut, and thence to the mouth the hill-slopes rise gradually from the water's edge.

The Connecticut is navigable to Hartford, 49½ miles from the mouth, for schooners and large steamboats, and by means of the Windsor Locks canal small boats are enabled to ascend as far as Holyoke; but the navigation above Hartford is of little consequence, and even in ascending to the latter city considerable trouble is experienced during low water by the larger craft. In former years, by means of canals around the various falls, navigation was carried on quite a distance above the northern Massachusetts line, or probably over 200 miles from the mouth; but the development of railroads put an end to such use of the river above the limits previously mentioned. More or less money is annually expended in dredging, and to some extent in more permanent works, such as wing-dams, on the navigable portion of the river. A plan has also been devised for a canal, to run from the head of the Enfield rapids to the mouth of the Hockanum river, a distance of about 17 miles. The estimated expense of carrying out this plan is $1,300,000, (*a*) but no appropriation has yet been made by Congress at all adequate for beginning work.

One of the most important interests on the river is that of lumbering. The timber is cut about the extreme upper waters, and consists almost entirely of spruce. At McIndoe's Falls it was stated that the annual "drive" down the river amounts to from 60,000,000 to 80,000,000 feet, of which from 10,000,000 to 12,000,000 feet are sawed at that point; the remainder passes down and is distributed among different mills as far south as Hartford, Connecticut.

The points at which the river is now utilized for power are, in order ascending, Windsor Locks, Connecticut, where a fall of about 30 feet is obtained; Holyoke, 59 feet; Turner's Falls, 41 feet; Bellows Falls, 54½ feet; Olcott falls (now being developed), 35 feet; and McIndoe's Falls, 12 feet. Above McIndoe's, in the extreme upper waters, there are said to be numerous dams, with falls of about 9 feet each, but these privileges are probably not all used for power.

Table showing the fall in the Connecticut river.

Locality.	Distance from mouth of river.	Height above tide.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Third lake	375	2,038	156	31	32.4	Hitchcock's *Atlas of New Hampshire.*
Second lake	369	1,882	264			Do.
Connecticut lake	361	1,618	583			Do.
West Stewartstown	344	1,035	150	32	4.7	Do.
North Stratford	312	885	55	27	[illegible]	Do.
Head of Fifteen-Mile falls	285	830	187	12	15.6	Do.
Lower Waterford	273	643	211	11	19.2	Do.
Foot of McIndoe's falls	262	432	25	7	3.6	Do.
Wells river	255	407	27	25	1.1	Do.
Oxford	230	380	5	17	0.3	Do.
Ledyard bridge, Hanover	213	375	36	4	9	Do.
White River Junction	209	339	35	13	2.7	Do.
Windsor	196	304	15	15	1	Do.
Beaver Meadows, Charlestown	181	289	6	11	0.5	Do.
Head of Bellows falls	170	283	49	0.5	....	Do.
Foot of Bellows falls	169.5	234	15	10.5	1.4	Do.
Westmoreland	159	219	13	23	0.6	Do.
Mouth of Ashuelot river	136	206	33	16	2.1	Do.
Top of Turner's Falls dam	120	172.93	75.24	....	....	W. P. Crocker, engineer of Turner's Falls Company.
Fitchburg Railroad crossing	115	109				Fitchburg Railroad profile.
Top of Holyoke dam	84	97.69	59.60	....	....	Elevation is 97.6 feet above low-water mark at Hartford, but is here referred to mean level of Long Island sound. (*a*)
Top of Enfield dam	65.6	38.09	31.80	5.2	6.1	Same datum plane as above. (*a*)
Foot of Enfield rapids	60.4	6.29	6.20	10.9	0.6	Do. (*a*)
Low-water mark at Hartford	49.5	0.09	0.09	49.5	....	Do. (*a*)
Mouth of river	....	0.00				

a From surveys by General Theodore G. Ellis, United States assistant engineer.

The volume of water flowing in the Connecticut river has been repeatedly measured at different points in its course. As stated in the introductory remarks regarding the flow of streams, the discharge at Hartford was noted daily for the eight years, 1871–'78, under the supervision of General Theodore G. Ellis, United States assistant engineer, and the results thus obtained are of the greatest value.

a *Report of the Chief of Engineers, U. S. army*, for 1881, page 568.

A number of careful measurements of flow have also been made at Hanover, New Hampshire, by Professor Robert Fletcher, of Dartmouth college, through whose kindness the following data were furnished.

Flow of the Connecticut river at Hanover, New Hampshire.

[Measurements (*a*) by Professor R. Fletcher.]

Date.	Stage of water.	Mean velocity of midstream per second.	Mean velocity per second of entire section.	Number of float observations.	Effective cross-section.	Greatest depth.	Average width.	Discharge per second.	Remarks.
		Feet.	*Feet.*		*Sq. feet.*	*Feet.*	*Feet.*	*Cub. feet.*	
September 20 and 21, 1879	Low		0.57		2,244	13½		1,280	Not very exact.
August 18, 1880	Very low				2,250	14½	235	No result.	
October 9, 1880	do	0.58	0.416	7	2,453	15	238	1,006	Not very exact.
October 26, 1880	Medium full banks	2	1.48	12	3,400	19.6	256	5,030	
June 9, 1881	Ordinary	1.9	1	9	3,250	17½	252	3,250	
October 14, 1881	Low	0.58	0.455	15	2,670	16½	240	1,210	
October 21, 1881	Ordinary	1.50		23	3,400	19	240	4,070	Best result yet obtained.

a Professor Fletcher states that these measurements were made "by the method of floating tubes and rods reaching to within a few inches of the bottom, so that each tube or rod would give approximately the mean velocity in that thread of the current. The results are generally a little too large, owing to unavoidable clearance below the tubes".

It is stated by Messrs. D. H. and J. C. Newton, of Holyoke, that September 1, 1882, in very lowest water (the streams generally ran remarkably low during the summer and fall of that year), a measurement of flow at Sumner's falls, a few miles below White River Junction and 10 or 12 miles below Hanover, showed it to be 1,377 cubic feet per second.

The flow in cubic feet per second to the square mile of drainage area, as shown by these various measurements, may be briefly presented as follows:

Flow of the Connecticut river relatively to drainage area.

Locality.	Drainage area.	Date of gauging.	Flow per second.	Flow per second to the square mile.	Remarks.
	Sq. miles.		*Cubic feet.*	*Cubic feet.*	
Hanover, New Hampshire	3,316	September 20 and 21, 1879	1,280	0.386	Low stage; result not very exact.
Do		October 9, 1880	1,006	0.303	Very low stage; result not very exact.
Do		October 26, 1880	5,030	1.517	Medium full banks.
Do		June 9, 1881	3,250	0.980	Ordinary stage.
Do		October 14, 1881	1,210	0.365	Low stage.
Do		October 21, 1881	4,070	1.227	Ordinary stage.
Sumner's falls	4,234	September 1, 1882	1,377	0.325	Extremely low stage.
Hartford	10,154	December 15, 1874	5,208	0.513	Lowest discharge for the eight years, 1871 to 1878.
Do			5,538	0.545	Average of lowest gaugings in each of the eight years, 1871 to 1878.
Do			5,000	0.492	Flow at zero of gauge, or assumed low-water mark.
Do		December 12, 1878	139,410	13.730	Highest discharge for the eight years, 1871 to 1878.
Do			113,291	11.157	Average of highest gaugings in each of the eight years, 1871 to 1878.
Do		May, 1854	205,464	20.235	Estimated discharge in highest freshet known.
Do			20,208	1.990	Average discharge for the entire eight years, 1871 to 1878.

DESCRIPTION OF WATER-POWERS.

Power at Windsor Locks.—The privilege to be described is located about a dozen miles above Hartford, and has been developed on the west bank of the river. The latter descends for 5 miles in rapids over a rocky bed, with a fall from still water above the rapids to still water below of 31.8 feet in ordinary low water, and of 33 feet in extreme low water.(*a*) The village of Windsor Locks is of moderate size (the entire town contains a population of 2,300), and would have no importance but for the manufacturing. It is 60 miles from Long Island sound, and accessible to a very limited extent for navigation by light-draught boats. The New York, New Haven, and Hartford railroad passes through the village along the right bank of the canal, on the opposite side of which are the mills. The country is somewhat hilly on either side of the river, rising, frequently by long gradual slopes, to sandy uplands.

The hydraulic improvements consist in the main of a dam at the head of the rapids and a canal 5¼ miles long down the west bank to the foot. They are stated to have cost, in round numbers, $200,000. The dam extends

a Report by General Theodore G. Ellis, in *Report of the Chief of Engineers, U. S. army*, for 1878.

across the river in a broken line, reaching well up stream, and has a total length of say 1,500 feet, more or less. The dam was built fifty years ago, and until lately consisted of two wings running out from either side of the river, and leaving at the center an opening of 150 feet for the passage of boats and rafts. It has a height of 3 feet at the center of the stream, rising considerably toward the abutments. It is built of logs and filled in with stone, slopes at once back from the crest, and from age and exposure is getting into poor condition. The opening near the middle of the river, which has been spoken of, has recently been closed by a section of new dam, 270 feet long, overlapping the opening and built just below the old dam, so that it can in time be conveniently extended clear across the river and take the place of the old structure. This new portion is also built as a timber and stone crib-work, in part bolted upon and in part sunk into bed rock, is 30 feet wide at the base, and has a sloping back, with a level top 12 or 15 feet wide. Midway of the length there is a fish-way 40 feet long. The new dam has been built perhaps 15 inches higher than the adjacent portions of the old one, and in consequence of the obstruction which has thus taken the place of the old water-way it is claimed that the river has been set back injuriously upon the water-privilege at Holyoke, 18 miles above, and the two water-power companies are now involved in a lawsuit upon the question. The bulkhead at the entrance of the canal is of sandstone rubble masonry in cement. About one-half of it has been rebuilt, and is much better work than the older portion. The new part has cut-stone piers, between which are turned brick arches, and is faced with oak timber on the up-stream side. There are in all fourteen gate-openings, each about 3 by 5 feet in size. A guard-lock, 19 feet wide, permits the passage of boats.

High ground rises so rapidly from the river that the canal nowhere runs more than about 150 feet distant from the latter and through a great part of its course the two are separated only by an artificial embankment formed of the material excavated from the side-hills. Some 3,500 feet below the bulkhead there was formerly a set of stop-gates, by which the water in the canal above them could be raised 5 feet, so as to equalize the pressure within and without and render the embankment more secure during high freshets, but only the piers of the gates now remain. The width of the canal ranges from 44 to 160 feet, averaging about 80 feet above the village of Windsor Locks and about 55 feet through the village. The present depth at the center is stated to be 6 feet, but it is designed to increase this to 7 feet, and correspondingly to alter the locks so as to admit boats of the same size as those on the Erie canal. Stony brook, a small stream, is crossed by the canal on an aqueduct about 100 feet long, of five 15-foot spans. From long use this aqueduct has come to need repairing; it is also somewhat leaky, and has insufficient capacity for properly passing the water required in the canal. It is now being rebuilt in part, and so widened as to give a clear breadth at water-surface of 83 feet. The mills are situated in a line along the river side of the canal, opposite the lower portion of the rapids. After passing the mills the canal descends to the river through three locks, which are in very poor condition.

The concerns in 1880 supplied with power were as follows: Seymour Paper Company; Windsor Locks Machine Company; A. W. Converse & Co., foundery and machine-shop; the E. Horton & Son Company, lathe-chucks; J. R. Montgomery & Co., cotton warps; Dwight, Skinner, & Co., wool graders and scourers; George P. Clark, patent rubber rollers; Medlicott Company, knit goods; C. H. Dexter & Sons, manila paper, flour, grain, feed, and lumber; Dwight Allen, silk manufacturer; F. H. Whittlesey, tissue paper; and the Farist & Windsor Steel Works.

There is but one level in use, water being drawn from the canal and discharged directly into the river. The falls obtained at the mills, in the most favorable stage of water, range from 20 to 26 or 28 feet. According to the returns of the census enumerators, the total horse-power of wheels in use here in 1880 was between 1,800 and 1,900. The owner of this water-privilege is the Connecticut River Company, which was chartered in 1824 by the state of Connecticut. The main object of the company appears to have been originally to assist the navigation of the river by providing a passage around the rapids,(*a*) and the needs of that interest must still be first served by the company, but navigation has really sunk to a position of minor importance in comparison with the use of the improvements for water-power. The Connecticut River Company gives a perpetual lease of water and land to users of its power. The rates actually charged vary according to circumstances, but the nominal water-rental is $2 50 per square inch under 30 inches head.(*b*)

a Lying opposite the town of Enfield, these are known as the "Enfield rapids".

b Assuming the discharge to be measured through a rectilinear opening in a thin vertical plate, with complete contraction, the head remaining constant, a square inch of water under 30 inches head, is equivalent according to Trautwine, to 0.05425 cubic foot per second. This corresponds to the gross or theoretical horse-power and, at the rate of $2 50 per square inch, to the prices given below, under various effective falls:

Equivalents of 1 *square inch under* 30 *inches head* = 0.05425 *cubic foot per second.*

Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.	Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.	Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.
Feet.		*Per H. P.*	*Feet.*		*Per H. P.*	*Feet.*		*Per H. P.*
20	0.123	$20 30	24	0.148	$16 90	28	0.173	$14 50
21	0.129	19 40	25	0.154	16 20	29	0.179	14 00
22	0.136	18 40	26	0.160	15 60	30	0.185	13 50
23	0.142	17 60	27	0.166	15 10			

NOTE.—With good turbines, from 60 to 80 per cent. of the theoretical power can ordinarily be realized.

With the fall at command at Windsor Locks the amount of power to be obtained from the Connecticut river is theoretically very great, though for realizing it most thoroughly, the present improvements are not the best suited. A canal of so great length as there employed has evident objections aside from the original cost, and by the location of the dam so far up stream a considerable amount of available storage room is lost. It is to be remembered, however, that the hydraulic works were designed mainly for the assistance of navigation, and they are therefore not to be judged wholly as water-power improvements. The question of a much greater extension in the use of power at this privilege must depend largely upon one or two contingencies. If the company should be permitted to maintain a continuous dam across the river of the height of the new section, it will have nearly the whole flow of the stream in its control, and by proper enlargements and extensions of the canal, which would no doubt be very expensive, could supply with power large additional manufacturing interests. If, on the other hand, it should be compelled to remove the obstruction caused by the new section of dam, and to leave a gap, as formerly, in midstream, the available supply of water would be no greater than heretofore. It is claimed, nevertheless, that even with that supply, with the canal of its contemplated enlarged dimensions as regards depth and width at the aqueduct, a very considerable increase in manufacturing can be accommodated, and there is much building-room still vacant along the lower course of the canal.

With the entire flow of the river at command, the gross or theoretical power at this privilege may be estimated as in the following table:

Estimate of the theoretical power of the Connecticut river at Windsor Locks under different falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.							Effective horse-power utilized in 1880.
		Spring.	Summer.	Autumn.	Winter.	Year.									
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. feet.*	1 *foot fall.*	20 *feet fall.*	25 *feet fall.*	28 *feet fall.*	30 *feet fall.*	31.8 *feet fall.*	33 *feet fall.*	
Low water, dry year	9,347	10	12	11	9	42	4,550	516.9	10,340	12,920	14,470	15,500	16,440	17,060	1,800–1,900
Low water, average year							4,900	556.6	11,130	13,920	15,590	16,700	17,700	18,370	
Available 10 months, average year							6,200	704.3	14,090	17,610	19,720	21,130	22,400	23,240	

Ice is a common hinderance experienced in New England in the use of water-power, and at Windsor Locks the principal inconvenience seems to arise, directly or indirectly, from that cause. Ice troubles there, both in the river and in the canal. A large amount of cake-ice runs down the river at the time of the spring break-up. The most dangerous run comes from below Holyoke, as the dam at the latter point holds back the ice in the river above, usually for a month after it has broken up in the section below, and allows it to rot before going out. The power of the floating ice is very great, and has been known easily to crush a heavy shore-wall near the Seymour Paper Company's mill, and this company, for protection, has been obliged to build a strong V-shaped ice-breaker. Even this, constructed in the most substantial manner and bound with iron straps, has been injured on at least one occasion.

On the rapids in the river thick ice cannot easily form, if it does at all; but skim-ice makes and floats down stream. On coming to an important obstruction, such as solid ice, it is pushed in under and causes a temporary gorging, until the pressure of the water is great enough to force a passage. This is natural to the river here, and has always been experienced more or less, but, being of short duration, was not formerly considered a serious hinderance. The gorge usually occurred about 1 mile below Windsor Locks. But the government having built a low pier, or wing-dam, some 5 or 6 miles below the village, a much more important and permanent gorging now occurs at that point in many winters, and is liable to occur in every winter. This causes backwater, which sets up over the foot of the rapids at Windsor Locks and permits the formation of thick ice where before it did not make. It causes a serious inconvenience to some, at least, of the mills, and the manager of the Seymour Paper Company stated that the building of the government pier had probably caused his company, indirectly, a loss of several thousand dollars. Its mill is the farthest up the river of any, and yet during an entire winter its head has been reduced constantly by as much as 5 feet. Spring high water also causes a reduction in head of perhaps 10 feet at times. The height of the flood seldom lasts more than twenty-four hours, and in some years there is an important loss of head for no more than a day or two, while in other years it continues for as much as two weeks.

Anchor-ice troubles both at the head-gates and in the canal. At the former it collects and hinders the working of the gates, while in the canal it clogs the racks at the entrances to the flumes, and gets into the wheel-pits and the wheels themselves. The Seymour Paper Company sometimes has to keep a man at work all night raking anchor-ice from its rack, and has also to introduce a jet of steam into the flume to disperse it there and keep it from the wheels. It is thought that trouble from anchor-ice in the canal has perhaps been aggravated

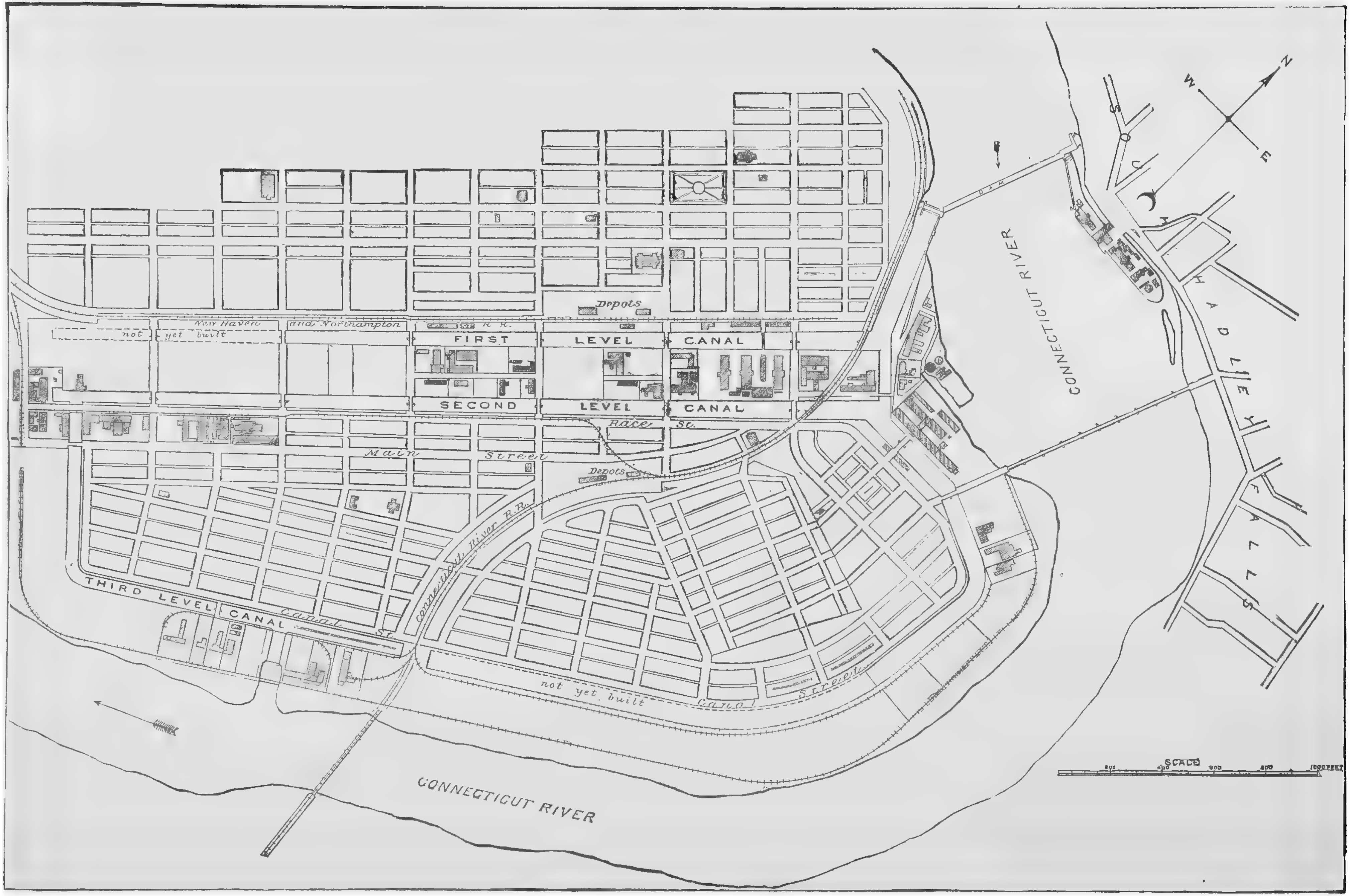

FIG. 11.—Plan of the City of Holyoke.

by the current being so swift at points that the surface of the canal did not freeze solidly over, and it is hoped that by the contemplated increase in the capacity of the latter the current will be reduced and the difficulty remedied.

In yet another way ice hinders seriously in the canal. Opposite the upper mills the current is swift enough so that thick surface-ice does not form; but below, toward the end of the canal, there is a nearer approach to dead water, and in consequence thick ice. Now, at the canal bulkhead, the direction of the dam serves to send skim-ice toward the gates; anchor-ice also forms there at times, as has been said, and from one or both causes a practical gorging ensues, and the entrance of water into the canal is much obstructed. The latter being drawn down by the mills, the surface-ice in the lower course breaks, sinks to the bottom, and there freezes to it. In this way, and perhaps by repeated occurrences, the canal becomes almost filled at the lower end with a solid mass of ice, and in extreme cases, as it was stated, "some of the mills could scarcely get water enough to put out a fire." When such an ice-clog forms, it has to be left until there comes a sufficient change in the weather to thaw it out.

Power at Holyoke.(*a*)—The river at this point makes a long but bold curve, and flows in rapids over a bed of gravel and ledge rock. The land inclosed by the bend is comparatively level, rising gradually away from the stream to hills of moderate height. The dam is on the upper part of the bend, while the canals run across and around it. On the north, or left bank, is the little village of South Hadley Falls, and on the opposite bank, or within the bend, is the city of Holyoke.

The first attempt to use the water-power here was made in 1831, when the Hadley Falls Company ran a 4,000 spindle cotton-mill, diverting water to its wheels by a wing-dam. As late as 1847 this and a grist-mill were the only users of power. The Hadley Falls Company failed in 1857, and in 1859 the Holyoke Water Power Company was organized, and bought out all the property and rights of the old company at a low price.

The first dam built entirely across the river at Holyoke was 30 feet high, and had a nearly vertical face, with a base of 60 feet; it was built of 12-inch square spruce timbers, forming a crib-work with a back slope of about 30° from the horizontal. To a height of 10 feet the interstices were filled with stone. The back slope was planked to the same height and covered with earth and gravel. Above this level gates were left, so that when the coffer-work was transferred to the other side of the river and that portion of the dam was being built, those gates in the already completed section served to pass the flow of the stream. The construction of the dam was finished and the gates were closed November 19, 1848. Leaks at once appeared beneath the structure, the base proved to be too small in proportion to the height, and in a few hours after the closing of the gates the dam was forced from its position and destroyed.

The second, or present, dam was completed October 22, 1849, and was built after a plan similar to that of the first, but giving greater width at base, and with greater precautions against leakage. It rests upon bed-rock throughout, to which it is strongly bolted; the various courses of timbers are also secured to each other by bolts. In construction this dam is a crib-work of 12-inch square timbers, the spaces partially filled in with broken stone. It differs from many high crib-work dams, in that the timbers running with the current are inclined up stream; they make an angle of about 23° with the horizon, and form bents 6 feet apart. A layer of *béton* at the foot of, and carried up a short distance on, the back slope prevents leakage under the dam. The crest is protected by boiler-iron. Forty-six gates, each 16 by 18 feet, were left in the dam during construction to permit the water of the stream to flow through temporarily. This, the original portion of the present structure, and what may be considered the dam proper, has a height at the crest of about 35 feet from the river-bed, a vertical face, and a base of about 88 feet.

The wearing action of the water pouring over this high fall, gradually scoured a depression 25 or 30 feet deep in the rock immediately below the dam, and rendered necessary the present apron, which was completed in 1870 at a cost of $263,000. It is a log crib-work, filled in with broken stone, extends 50 feet down stream from the main dam, its upper surface having a slope of about 25°, and drops off vertically at the down-stream end.

The roll-way of the Holyoke dam is 1,017 feet long. The abutments, bulkheads, lock-walls, and waste-weirs are all strongly built of rock-faced cement masonry, and the up-stream face of the main bulkhead is dressed smooth. The north, or Hadley Falls abutment, extends back a distance of about 90 feet, measured from its upper edge next the river in to the lock-opening. For 12 feet back from the river it is 24 feet wide on top, and for the remaining distance 13 or 14 feet wide. Adjacent to the lock-opening is the bulkhead, measuring about 20 feet in length between the outer walls. Between the bulkhead and the bank is a lock 16 feet wide, formerly used, as well as the canal below, for navigation purposes. From the bulkhead a canal from 800 to 1,000 feet long leads down the left bank to three mills, using in the neighborhood of 35 feet fall and discharging directly into the river. This canal has a clear waste-way, just below the bulkhead, of about 30 feet, and 16 feet more taken up by an old and apparently neglected fish-way.

Measured from the south end of the dam, the distance along the top of the adjacent abutment and bulkhead to the lock-opening is 172 feet. The bulkhead is about 40 feet wide with the current, contains twelve large gate-

a Information regarding this power was kindly furnished by Mr. Clemens Herschel, hydraulic engineer of the Holyoke Water Power Company.

openings, each 8 feet wide by 15 feet deep, separated by piers about 19 inches thick; and also two smaller gate-openings, each 4½ feet wide by 10½ feet deep; it is surmounted by a brick building, in which is the machinery for working the gates. At one end of the building is a turbine, furnishing power. It acts directly to turn a long horizontal shaft running lengthwise of the building, above the gates. Each of the latter has two vertical wooden posts, 10 by 13 inches in size, fastened to it and faced on one side with iron racks. The long shaft, operated by the turbine, in turn, by connecting belts, causes a series of cog-wheels to revolve, the last of these engaging and moving the racks already mentioned, and with them the gates. Each gate can be moved independently of every other. Commonly the water stands higher outside the gates than in the canal; at such times they are not raised to the full height, and in consequence of the pressure, power is required to close them; but in low water the gates are raised entirely above its surface, and their weight alone is sufficient to close them.

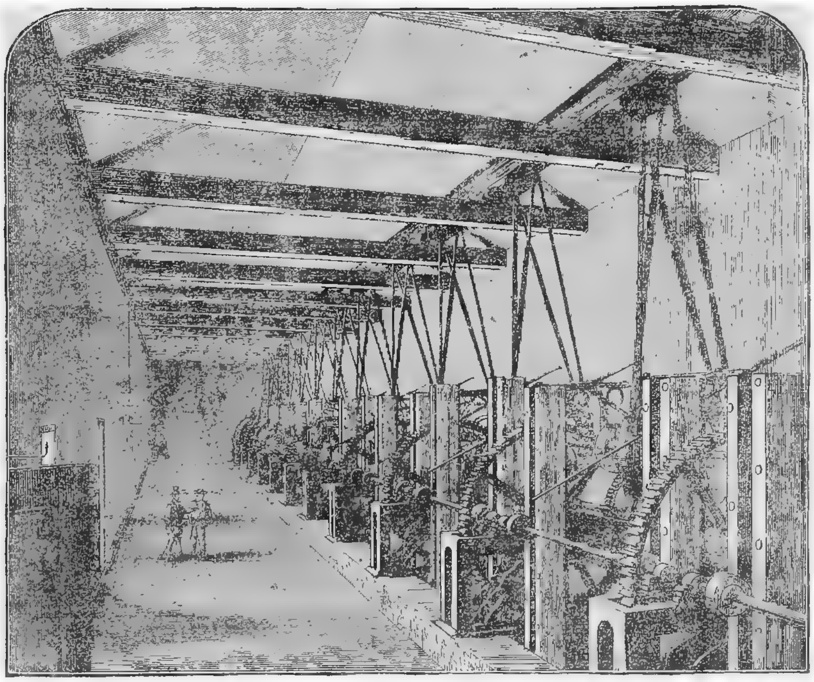

FIG. 15.—Interior view of gate-house, Holyoke.

Adjacent to the bulkhead, and forming the river-wall of the main canal, is a waste-weir 198½ feet long; it is constructed of solid masonry, and rises to within 20 or 24 inches of the top of the gate-openings in the bulkhead; for the remaining height above its crest the water-surface in the canal is controlled by temporary flash-boards. Of the 198½ feet of length, 40 feet rises above the surface of the water in the canal, and about 5 feet above the crest of the waste-weir proper. This portion is pierced by four waste-gates, their centers about 20 feet below the normal water-surface in the canal; these gate-openings measure 5 feet in width, and from 5 feet to 65 inches in depth.

The system of canals at Holyoke comprises three levels from which water is drawn. The first or upper level strikes off across the bend which the river forms, and runs at a distance of from 2,800 to 3,400 feet from the latter; it has a total length of 5,700 feet at present, and decreases in width from 150 feet near the bulkhead to say 105 feet at the lower end. The water depth is about 20 feet near the bulkhead, but through the main portion of the canal is uniformly about 10 feet. This canal is walled throughout its length with dry stone, to a height generally of 2 or 3 feet above the water-surface, and is the only one of the three canals that has been completely walled. The fall from this level to the second is 20 feet. Near the upper end a few mills discharge from it directly into the river, using falls of from 32 to 40 feet. The second level runs parallel to the first and 400 feet nearer the river, forming a straight reach of 6,500 feet; continuing from the upper end, it also sweeps around through a further distance of 2,600 feet at present, running parallel to the curving course of the river and 500 feet distant from it. Its width decreases from 150 feet at the upper end to 90 feet at the lower end of the straight reach, and in the curving portion lies mainly between 140 and 150 feet. The water depth in this level is uniformly about 8 feet. The supply of water comes from the first level, partly as tail-water from the mills and partly from the waste-weir and gates between the two levels. The fall to the third level is 11½ or 12 feet, and from the second level to the river from 25 to 28 feet. The third level, for part of its course, runs parallel to the river, at a distance from it of say 500 feet. It has a total length of from 3,500 to 4,000 feet, a width of about 100 feet, and a water depth of 8 feet. The fall from this level to the river is substantially the same for all the mills using it, but, according to the stage of river, ranges from 15 to 27 feet.

In addition to the waste-weir, already described, near the bulkhead, having a length of about 200 feet, and discharging into the river, there is another, of 40 feet, over which water descends from the first to the second level. Closely adjacent, the second level has a waste-weir 100 feet long, toward the river, which the overflowing water reaches through four arched openings underground. At the lower end of the second level there is another weir, 80 feet long, over which water spills to the third level. The latter has a similar weir, 150 feet long, connecting with the river. These various weirs do not rise to the ordinary level of the water-surface, but are surmounted by temporary flash-boards, varying from 18 inches to 2 and even 3 feet in height, used for maintaining the proper level. At each weir there are also waste-gates at or near the bottom, which may be used in connection with the flash-boards for regulating the level, or for drawing it down altogether.

Holyoke is distant by rail 144 miles from New York, 106 from Boston, 103 from Albany, and 84 by water from the mouth of the Connecticut, with a very limited navigation over the latter distance. The Connecticut River

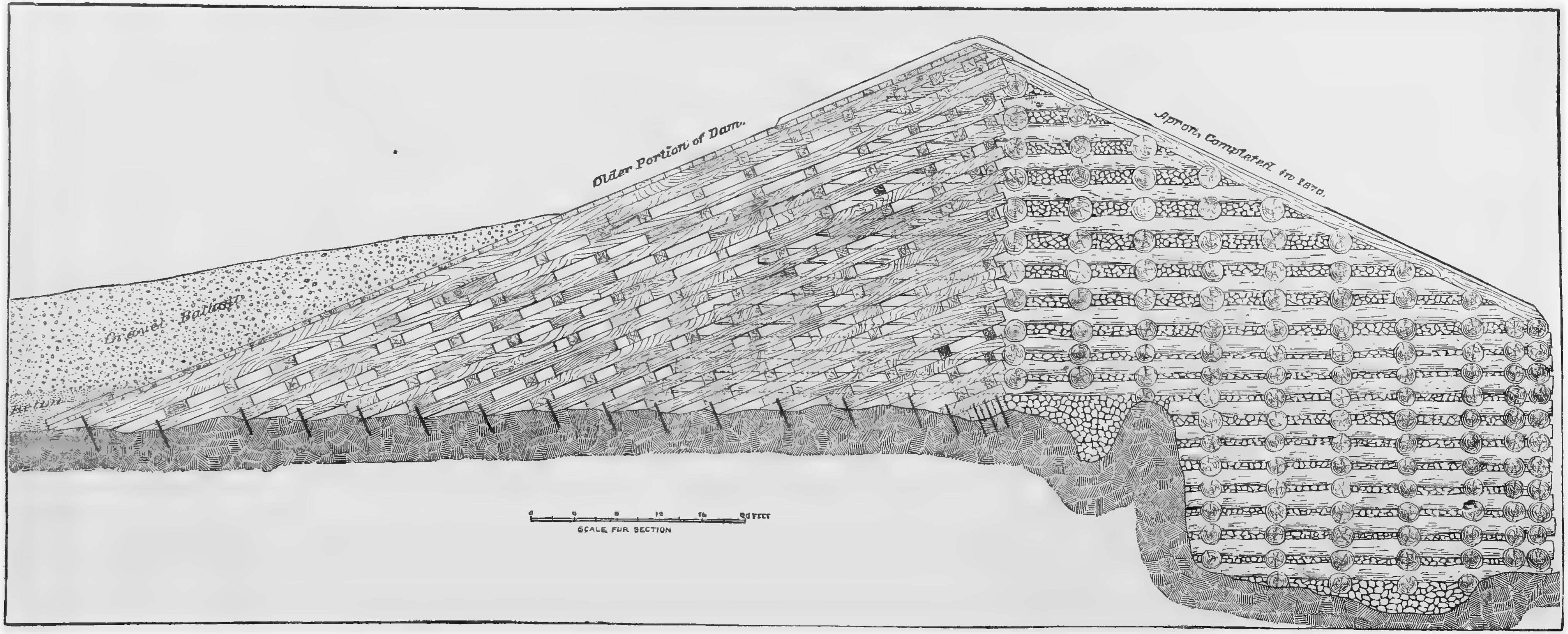

FIG. 12.—Cross-section of Holyoke Dam.

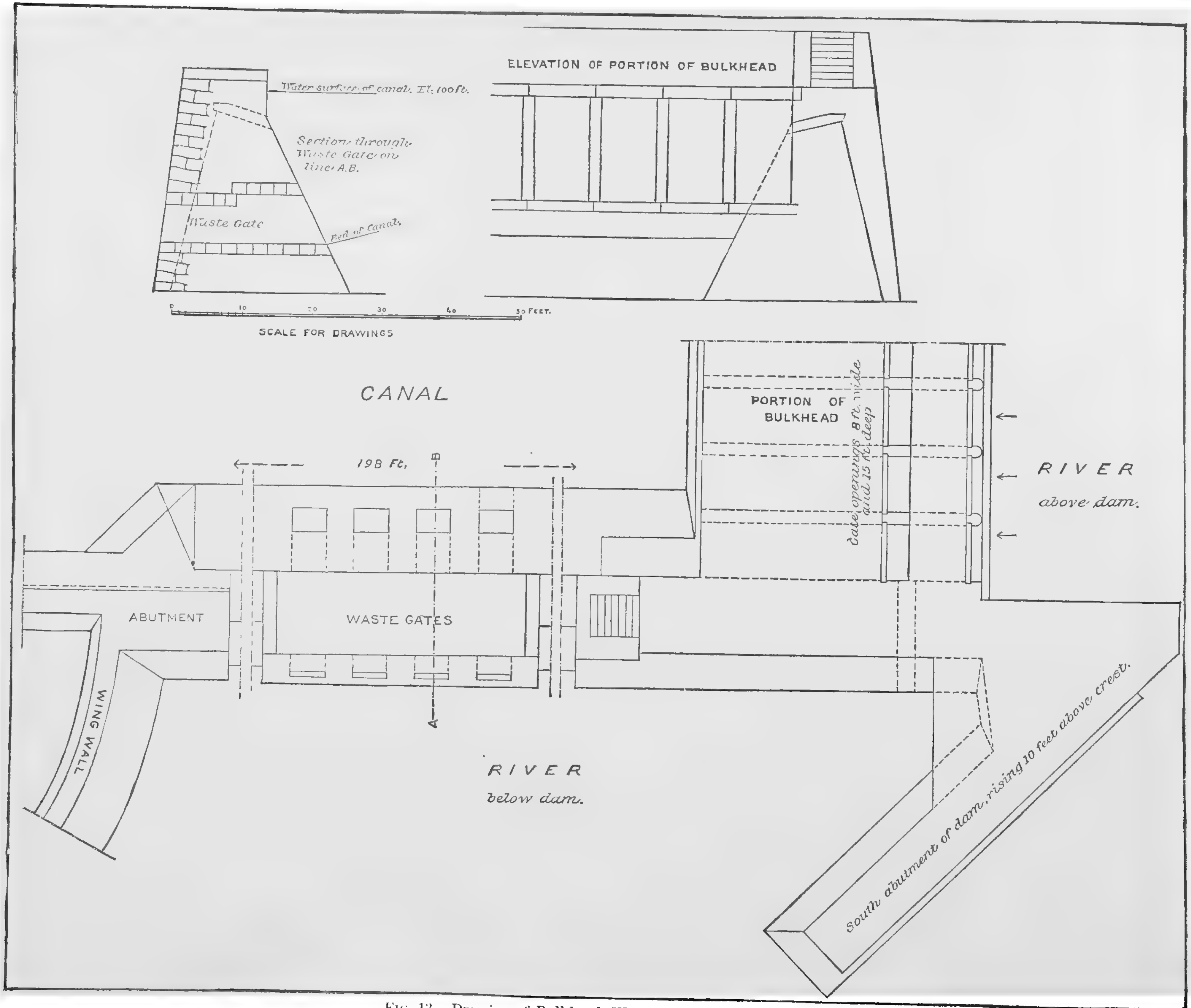

FIG. 13.—Drawing of Bulkhead, Waste weir, etc., Holyoke.

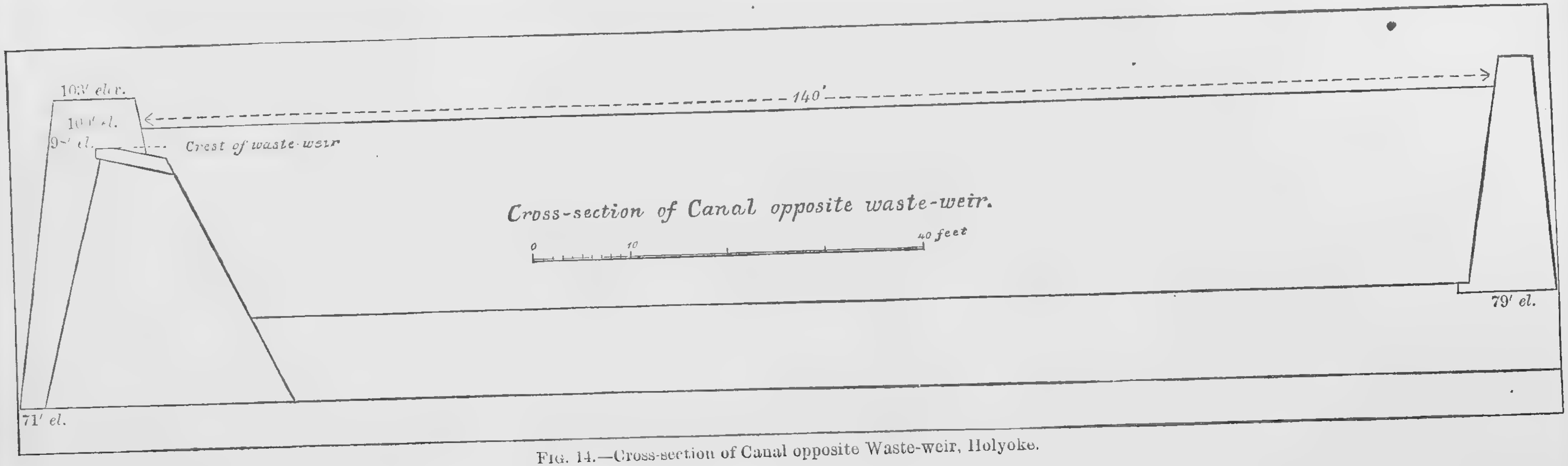

FIG. 14.—Cross-section of Canal opposite Waste-weir, Holyoke.

railroad, running from Springfield northward, passes through the city, and the latter is also entered by a branch from Westfield of the New Haven and Northampton railroad. Spur-tracks from these roads skirt almost the entire courses of the canals, giving great convenience to the mills for shipping. From the mere village of twenty-five years ago Holyoke had grown to be a city of 22,000 inhabitants in 1880, having doubled her population in the preceding ten years. It would be difficult to find any manufacturing city giving greater evidence of substantial development and prosperity than this. The interests are very considerably diversified; the mills are fine modern structures of brick, and in numerous cases of great size. The city contains handsome churches, schools, and other public buildings; the signs of life and great activity are everywhere present, and at the basis of all is a splendid water-power, admirably developed and enjoying a thoroughness and scientific method of management that are probably nowhere surpassed.

The water-privilege and such manufacturing sites and other lands as have not already been disposed of are controlled by the Holyoke Water Power Company, having a capital stock of $600,000.(*a*) This company owns undisputed about 56 feet of fall from the top of its dam down to smooth water at a low stage below the third level; it also claims about 3 feet more fall, but that is involved in a dispute and lawsuit with the Connecticut River Company, proprietors of the privilege at Windsor Locks. Not only does the company sell land and lease power to be improved by other parties, but it has itself built several fine mills in which it rents room and power to various concerns. When there is abundant surplus water it uses that as a source of power for these mills, but at other times steam.

Two articles in the "Proposals by the Holyoke Water Power Company for the sale of its mill-powers and land at Holyoke, Massachusetts", are as follows:

ARTICLE II. Each mill-power at the respective falls is declared to be the right, during sixteen hours in a day, to draw from the nearest canal or water-course of the grantors, and through the land to be granted, 38 cubic feet of water per second at the upper fall, when the head and fall (*b*) there is 20 feet, or a quantity inversely proportional to the height at the other falls; and in order to prevent dispute as to the power of each mill privilege in the variations of the height of the water from changes of the seasons or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them; thus, on a head and fall of 32 feet, the quantity of water to be used would be 23 cubic feet and $\frac{9}{31}$ parts of a cubic foot per second. And the respective parties, where either has any lawful interest therein, may at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the race-way thereof to measure and compare the quantity of water used with the quantity granted, and in the measurement all wastage shall be included; and may also adopt and use such other mode of making or verifying the said measurement as the circumstances of each particular case may require.

* * * * * * * * *

ARTICLE V. In order to continue in the grantors an interest in common with the grantees for the preservation and support of the mill-powers which may be granted, and to secure a fund to indemnify the grantees for expenses which may be incurred by them for making repairs, if the grantors should improperly neglect to make them, it is proposed that part of the consideration of every sale, and all that is to be allowed the grantors for the repairs, etc., by them assumed, should be paid or secured to them in the form of a reservation of rent.

It is therefore declared, That each mill-power, with the land to which it is annexed, shall forever be subject to a perpetual annual rent of at least 260 ounces, troy weight, of silver of the present standard fineness of the silver coin of the United States, or an equivalent of gold, at the option of the grantee, at the time of payment; which rent is to be paid in yearly payments forever, free from all charges or deduction whatever for taxes or assessments of every description which may be assessed or levied upon any granted premises after the making of the deed, all of which are assumed by the grantees; and a perpetual annual rent at least equal to the above shall be reserved for every mill-power hereafter sold.

As regards rights to water, no priority is observed among those having lease of permanent power. The rates charged for power have varied at different periods in the company's history, and according to the peculiar circumstances of each case. The rental per mill-power, which is often expressed as the rate charged at Holyoke, indicates but little as to the actual cost of the power to a manufacturer. It is merely a *minimum reservation* to insure a permanent income for keeping the power in order. When a company wishes to secure power it also buys land, and, the transaction being made as a whole, the actual cost of the power alone is to a certain extent therein included, and can not well be stated separately. The rates charged now, when the city has a population of over 20,000, are naturally higher than they were when the place was in its infancy and only a small village existed.

There are two classes of power in use at Holyoke, permanent and surplus. As many as twenty-five of the latter will soon be employed. Every lessee of permanent power is entitled to use a surplus, when it can be furnished, of 50 per cent. of his lawful amount, at the rate of $2 50 per day, or night, per mill-power. (*c*) For all over 50 per cent. surplus he must pay at double this rate. There is a limitation, however, in time of drought; then only a certain total surplus,

a In March, 1883, the shares, $100 par, were quoted at $220 bid.

b The term "head and fall" is an old one, and has but little significance at the present time. When overshot or other vertical wheels were more commonly in use it was convenient to distinguish between that small portion of the entire available fall employed in giving velocity to the water as it strikes the wheel, and the remainder of the fall through which the water acts by its weight; a similar distinction might perhaps be made where a small portion of the entire head is consumed in producing a fall over a weir for the purpose of measuring the water used by the wheels; but for all ordinary purposes the terms "head", "fall", "head and fall", may be taken as synonymous unless otherwise stated.

c As defined in Article 2, previously quoted, a mill-power is, under ordinary circumstances, equivalent to 38 cubic feet per second under 20 feet fall, or about 86.3 theoretical horse-power. Accordingly as the efficiency of the turbines employed ranges say from 60 to 80 per cent., the net or effective value of the mill-power will range from 51.8 to 69 horse-power.

as, for instance, 40, 20, 10 per cent., and so on, depending upon the supply of water in the control of the water-power company, can be drawn. The company fixes the percentage of surplus that shall be allowed, and changes it when necessary, without preliminary notice. All the mills are to be connected with the company's office, so that instantaneous notification can be given to decrease the use of water. If, notwithstanding the notification, a manufacturer persist in using surplus beyond the allowed amount, then he must pay ten times what would otherwise be due. During the summer of 1882, one of the driest on record, the first limitation went into effect August 4, and for about three weeks during the season the mills were subject to limitation of some kind. In order to insure having sufficient power always to enable them to fill their orders, some of the mills are putting in steam for auxiliary use.

In October, 1882, the amount of effective horse-power in use at Holyoke was stated to be about 8,000 by night and 15,000 by day, or an average of say 11,000 or 12,000 for the twenty-four hours. It is difficult to say just how much power can be depended on here in low stages of river. During the very dry summer of 1882 there was some scarcity of water during four nights, and it was stated by Mr. Herschel as probable that on some days the average power in use for the twenty-four hours did not exceed 10,000 effective horse-power. Every possible economy is practiced at Holyoke, by the water-power company, in the use of water, and the river is carefully watched; from as far up as Bellows Falls any important rise is telegraphed down during the dry season, so that it may be anticipated, and the possible necessity of curtailing the supply to the mills be avoided. The slope of the river above Holyoke is small and a large pondage is secured; with 2 feet of flash-boards on the dam the effect of back-water becomes imperceptible, at a low stage of river, 20 miles above. So far as concerns an increase of power, the pondage is of much less consequence here than upon a cotton-manufacturing stream such as the Quinebaug or Shetucket. At Holyoke the great bulk of the water is used by paper-mills which run steadily night and day, and thus give little opportunity for concentration of power within a part of the twenty-four hours. The pond is not allowed to be drawn down more than 2 feet below the crest of the dam, or 4 feet below the top of the flash-boards.

Regarding an increased use of water-power at this point, it may be said that the company can guarantee power in the future only to a very limited extent and on certain levels. During the continuance of the present dispute with the Connecticut River Company, which affects the third level, it does not wish to dispose of any more power on that level. There is a particularly large number of paper-mills on the third level, requiring a considerable amount of night water to be drawn through the two upper levels for their use; it therefore happens that permanent night power can still be obtained on the first level (October, 1882), and between the second and third levels there is a large unoccupied mill site, for which power can be obtained that shall be permanent in night and practically so in day.

FIG. 16.—First-level canal, from gate-house, Holyoke.

Within a quarter of a mile or so of the dam, and located on either bank of the river, there are several important mills which draw water from the adjacent level and discharge directly into the river, without utilizing the entire fall that the water would have if discharged successively from one level to another and then into the river finally at the foot of the rapids. This difficulty is a common one, however, with large water-privileges. The development of a great power is a costly enterprise, and can seldom be carried out, in the start, as a completed design; canals are extended and other improvements made only as business and revenues warrant, and so it often happens that some sites are disposed of which are unfavorable to the full utilization of the available power. It is not unlikely that the same fault sometimes arises from too sanguine ideas as to the capacities of a privilege relatively to the demands which will be made upon it.

No measurements of the volume of the river at this locality could be learned of, other than one said to have been made in the summer of 1847, when the discharge in a low stage was found to be 6,000 cubic feet per second. From a careful examination of the results obtained for the discharge at Hartford, by General Ellis, during the years 1871-'78, the following estimate has been made of the power at Holyoke:

Estimate of theoretical power at Holyoke.

Stage of river.	Drainage area.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 ft. fall.	56 ft. fall.	59 ft. fall.	Power utilized.
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cu. feet.*				
Low water, dry year	8,006	10½	12	11	9½	43	3,800	431.68	24,170	25,470	In October, 1882, there were stated to be in use about 8,000 effective horse-power by night and 15,000 by day. According to the census enumerator's returns there were in 1880 12,260 effective horse-power of wheels in use.
Low water, average year							4,100	465.76	26,080	27,480	
Available 11 months, average year							4,450	505.52	28,310	29,820	
Available 10 months, average year							5,250	596.40	33,400	35,190	
Available 9 months, average year							5,700	647.52	36,260	38,200	
Available 8 months, average year							6,650	755.44	42,300	44,570	
Available 7 months, average year							8,100	920.16	51,530	54,290	
Available 6 months, average year							9,700	1,101.92	61,710	65,010	

NOTE.—The estimates of power available for 9, 8, 7, and 6 months, respectively, must be regarded as less reliable than the others; they may have no especial practical value, but may be of interest in showing the great increase in the use of power possible for a part of the year by using steam for the remainder.

As to freshets, there has on several occasions been a depth of 6 feet of water on the dam, and such was the case after the heavy rains of September, 1882. At one time, years ago, there is said to have been a depth of 11 feet (*a*) on the dam, but at that time 4-foot flash-boards extended part-way across, and it cannot be known how far they affected the height; it is certain, however, that the water rose above the tops of the abutments. Surface-ice usually rots in the pond before moving out. As a precaution, a V-shaped piece is cut in the ice above the dam, and when it does run out the sides of this opening close together and relieve the abutments from pressure. Anchor-ice causes no trouble worth mentioning, affecting for a day or two only a single mill, and the difficulty might easily be overcome there.

In noticing the manufacturing interests of Holyoke, the paper industry must of course be given the greatest prominence. So far as known, this city is the most important center of that enterprise in the United States. In October, 1882, twenty-three concerns were engaged in the manufacture of paper, employing over 4,000 hands, and turning out a finished production of from 150 to 160 tons per day. Almost every variety of paper seems to be made, though fine writing-papers occupy the chief place. Paper is also here made into blank-books, envelopes, and paper boxes. Spool-cotton, cotton yarn, and cloth are extensively manufactured, the Lyman, Hadley, Merrick, Hampden, and Glasgow mills together running 180,000 spindles. Other leading manufactures comprise woolen goods, silks, water-wheels, pumps, and various other kinds of machinery, screws, cutlery, rubber goods, wire-cloth, and, in a less prominent degree, numerous other articles.

The following table, which embraces all the most important manufacturing establishments of the city, will give in more detail facts regarding the above interests:

Statistics of manufacturing at Holyoke, October, 1882.

[The figures below are approximately correct, but were not intended to be given with minute accuracy.]

Firm.	Manufacture.	Number of hands employed.	Production, etc.
Carew Manufacturing Company	Superfine writing paper	100	2½ tons per day.
Hampshire Paper Company	Extra superfine writing paper	175	3 tons per day.
Parsons Paper Company	White and tinted writing and envelope paper; also bond, bank-note, parchment, linen, ledger, and record papers.	350	10 tons per day.
Whiting Paper Company	Fine writing paper	600	14 tons per day.
Wauregan Paper Company	Superfine book and superfine engine-sized writing papers.	130	6 tons per day.
Robertson Brothers	Tissue, manila, and toilet papers	12	35 cases per day.
Holyoke Paper Company	Fine writing paper	275	7 tons per day.
Whitman Manufacturing Company	Lithograph, white-plated, and chromo papers, and card-board.	....	
Beebee & Holbrook Company	Fine writing paper	115	3 tons per day.
Massasoit Paper Company	....do	200	3 tons per day.
Chemical Paper Company	Manila papers	250	20 tons per day.
Newton Paper Company	Building, carpet-lining, and heavy wrapping papers.	60	12 tons per day.
Excelsior Paper Company	Machine-finished book papers	55	3 tons per day.
Franklin Paper Company	Colored, flat, writing, and envelope papers	80	3 tons per day.

a General Ellis states the greatest depth above the dam at 13 feet, in April, 1862 (see page 54, *Report of Surveys and Examinations of the Connecticut River*).

Statistics of manufacturing at Holyoke October, 1882—Continued.

Firm.	Manufacture.	Number of hands employed.	Production, etc.
Union Paper Company	Fine writing paper	175	From 4 to 5 tons per day.
Riverside Paper Company	do	225	5 tons per day.
Winona Paper Company	Engine-sized writing and super-calendered book papers.	130	11 tons per day.
Syms & Dudley Paper Company	Engine-sized flat and ruled writing, card-board, and book papers.	180	12 tons per day.
Nonotuck Paper Company	Engine-sized flat writing, and book papers	200	10 tons per day.
Albion Paper Company	Book paper	250	15 tons per day.
Crocker Manufacturing Company	Various kinds of engine-sized papers	75	From 4 to 5 tons per day.
Valley Paper Company	Fine writing paper	225	5½ tons per day.
Dickinson & Clark Paper Company	Engine-sized writing and book papers	65	From 3 to 4 tons per day.
National Blank Book Company	Blank books	200	Value of yearly production, from $300,000 to $400,000.
Holyoke Envelope Company	Envelopes	100	1,000,000 envelopes per day.
James D. Whitmore & Co	Envelopes and paper boxes	80	
Connecticut River Pulp Company	Wood-pulp	50	10 tons per day.
Glasgow Company	Dress goods, ginghams, and yarns	425	13,000 spindles; 400 looms. Production, 75,000 yards per week.
Hampden Cotton Mills	Heavy duck	500	15,000 spindles; 350 looms. Production, 1,250,000 pounds of finished goods per year.
Lyman Mills	Sheetings, shirtings, and lawns	1,200	75,000 spindles; 1,600 looms. Production, 14,500,000 yards of finished goods per year.
Holyoke Warp Company	Cotton warps	125	1,500 pounds per day.
Merrick Thread Company	Spool-cotton		35,000 spindles. Production, 3,000,000 dozen spools of cotton per year.
Hadley Company	Spool-cottons, yarns, warps, and twines	725	42,000 spindles. Spins 1,325,000 pounds per year.
Farr Alpaca Company	Alpaca	1,000	577 looms run.
D. Mackintosh & Son	Dyed cottons		75 cards. Production, 8,500 pounds per day.
Germania Mills	Beavers, fancy goods, cloakings, and overcoatings	300	74 looms; 16 sets of cards. Production, 6,000 pieces per year.
Connor Brothers	Fancy cassimeres		11 sets of cards; 65 looms.
Beebee, Webber, & Co	do	135	32 looms; 8 sets of cards. Production, 30,000 yards per month.
Springfield Blanket Company	Horse-blankets	300	180 looms. Production, 1,800 blankets per day.
William Skinner & Son	Silk and mohair braid, machine-twist and sewing-silk, satin sleeve-linings.	350	
George W. Prentice & Co	All kinds of iron and soft steel wire	60	3 tons of wire per day.
Holyoke Machine Company	Mainly water-wheels, mill-gearing, and paper-mill machinery.	300	Value of production, $500,000 per annum.
Massachusetts Screw Company	Wood-screws	75	3,000 gross of screws per day.
Henry Seymour Cutlery Company	Shears and scissors	70	From 2,400 to 2,600 dozen pairs per month.
Deane Steam Pump Company	Pumps and machinery of all kinds	120	
John C. Smith	Machine-shop	50	
Watson Ely & Son	Carpentry, mill-work, and sawing	20	
T. F. Keegan	Steam-fitting	16	
Tuttle Rubber Works	General rubber goods	26	Value of production, $60,000 per year.
Ferguson & Gardner	Leather belting and top-roll covers		
B. F. Nichols	do	10	Covers, 10,000 rolls per week.
Buchanan, Bolt & Co	Wire-cloth		
B. F. Perkins	Machine jobbing	10	

Power at Turner's Falls.(a)—The village of Turner's Falls is beautifully located in northern Massachusetts, a short distance from Greenfield. It is about 120 miles from the mouth of the Connecticut, though without water communication; it is only 2 or 3 miles from the main lines of the Fitchburg, the New London Northern, and the Connecticut River (b) railroads, but is directly reached only by branches of the Fitchburg and the New Haven and Northampton roads.

In 1792 the state of Massachusetts incorporated the "Proprietors of the Locks and Canals on Connecticut River", for the purpose of rendering that stream passable from the mouth of the Chicopee river northward. In 1794 this corporation was formed into two, one bearing the old title and the other known as the "Proprietors of the Upper Locks and Canals". The former built the dam and canal at Holyoke, while the latter improved the river at Turner's Falls. The dams and canal at this point were completed in 1798, and the upper dam, near the mouth of Miller's river, was built in 1800.

For more than half a century this company transacted a profitable business in passing boats and lumber through their locks and canals, until the construction of railroads on the banks of the Connecticut river put an end to the business of transportation by water, and the works of the company went into disuse. In 1865 every share of the original stock was purchased by a number of gentlemen, * * * and in 1866 an amendatory act of the legislature was passed, giving to the corporation the name of "Turner's Falls Company". During the same year additional lands were purchased, making an area of about 700 acres; a substantial bulkhead was constructed at an expense of $24,000, and a permanent dam was completed March 20, 1867, at a cost of $105,000.(c)

a Facts regarding this privilege were kindly furnished by Mr. William P. Crocker, engineer of the Turner's Falls Company.

b Opposite side of the river.

c From prospectus of Turner's Falls Company.

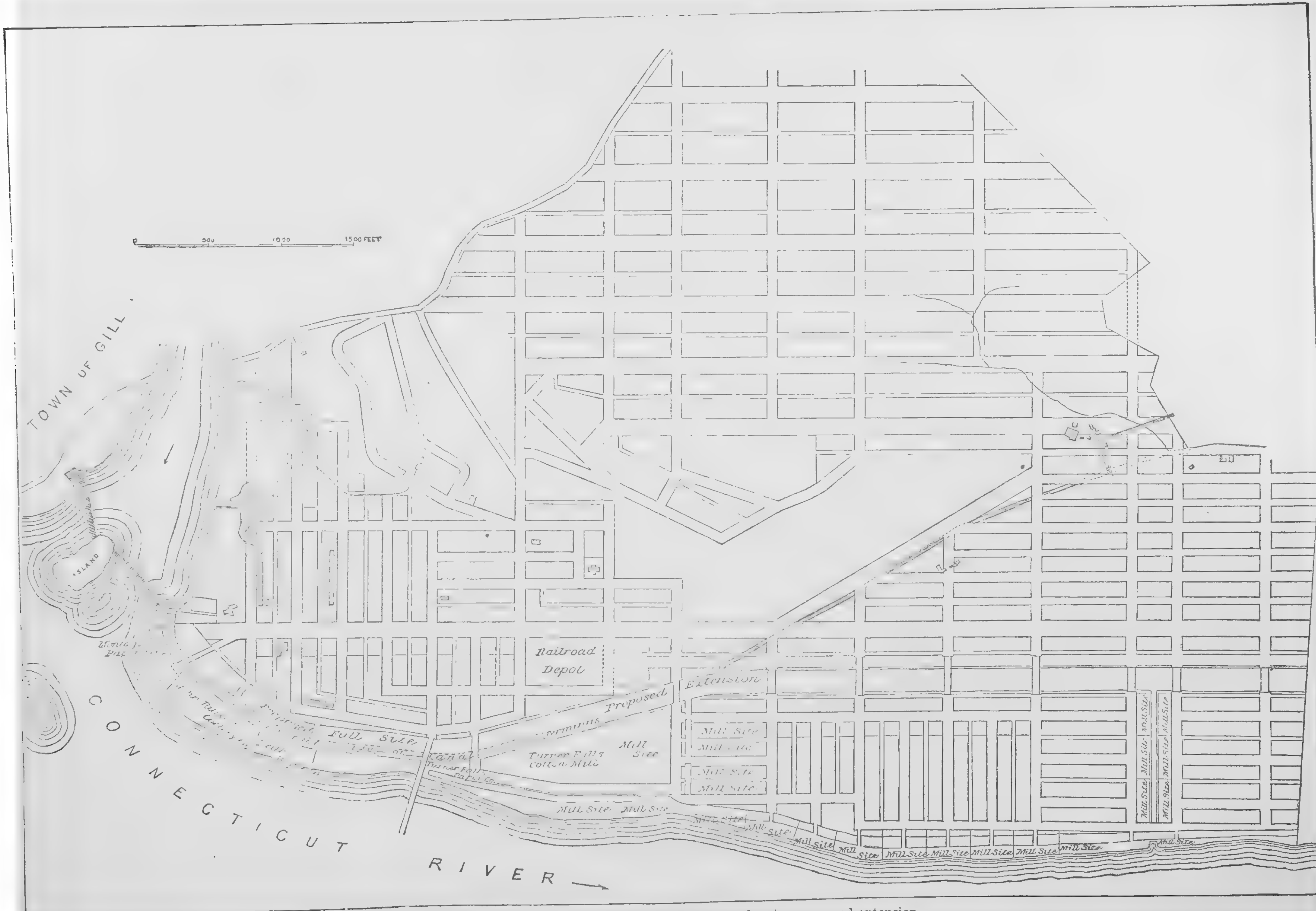

FIG. 17.—Plan of the Privilege at Turner's Falls, showing proposed extension.

At Turner's Falls the river runs northerly for a short distance and then bends sharply to the west and south. The right bank is steep and rocky; the mills and village are on the left bank, which rises somewhat rapidly from the river, but is succeeded beyond by gently hilly ground. Passing a short distance down stream, or toward the foot of the canal, the hills recede from the river on this side, and leave a fine level plain which is not yet built up.

On the upper part of the bend in the river is the dam. It runs across from the left bank, with a slight curve up stream, to a rocky island in midstream, and then continues with straight course to the right bank. In the autumn of 1866 a portion of the present dam, then in process of construction, was destroyed by a timber raft, which broke loose from its moorings during a freshet and came down against the coffer-work with irresistible force. Work was recommenced and carried on through the winter of 1866–'67; the structure was finished March 20 of the latter year, only three days before the occurrence of a heavy freshet. In 1880 the entire cost of the roll-way of the dam was placed at $113,000, and of the bulkhead at $35,000. The Turner's Falls dam rests throughout on ledge rock, and varies from 20 to 30 feet in height. It is a log crib-work, the interstices packed with loose stone. The face has a slight batter, while the back has a long slope, giving, for a height of 20 feet, a base of perhaps 50 or 60 feet. The roll-way is very nearly 1,000 feet long. The elevation of the crest is stated to be 172.9 feet above sea-level.

The dam abuts against natural ledges everywhere except on the Turner's Falls shore. Here is an artificial masonry abutment and bulkhead, about 150 feet long by 35 feet wide, and rising 15 feet above the crest of the dam. (*a*) It is solid for a short distance back from the end of the dam; farther inshore are five arched openings through which water passes to the gates. There are five gate-openings, each 8 feet wide and 10 feet deep. Water also enters a side-opening into a wheel-pit, and drives a turbine for operating the gates. After passing through the rectangular gate-openings the main body of water continues through arched openings similar to the ones already mentioned, till, having passed entirely through the bulkhead, it enters the canal.

The canal is at present confined to one level, extending about 3,000 feet, approximately parallel to the river, and at a distance from it varying from 100 to 250 feet in the main part of its course, but increasing to 500 or 600 feet toward the end. It has an average width of 50 feet as at present constructed, and a water depth of 10 feet. Close to the dam the fall to the river is about 28 feet, and the greatest fall utilized on the line of the canal is 41 feet. This race has been largely excavated through rock, and has therefore been expensive; according to a report by the president of the company, made in June, 1871, its cost up to that time had been $82,000. One hundred feet of land on the easterly side of the race is reserved for giving it additional width when occasion shall demand.

The power in use at this point in the fall of 1882 was stated to be about 4,000 horse-power, which exceeded, however, the amount actually leased. The concerns using power at that time were as follows:

1. The Clark & Chapman Machine Company.
2. The Shawmut Manufacturing Company (rents power from the above concern), employing 6 hands in the manufacture of leatheret.
3. The Montague Paper Company, printing paper; 260 hands; production, 15 tons per day.
4. The John Russell Cutlery Company, general cutlery; 700 hands; turns out 3,000 dozen pieces per day.
5. The Keith Paper Company, fine writing paper; 225 hands; production, 5 tons per day.
6. The Turner's Falls Paper Company, news paper; 35 hands; production, 5 tons per day.
7. The Turner's Falls Cotton Mill, light cotton goods; 5,100 spindles; 300 looms; 150 hands; annual production, 4,500,000 yards.
8. On the opposite (Gill) side of the river, the Turner's Falls Lumber Company, saw-mills, employs 35 or 40 men, and turns out about 27,000 feet of lumber per day.

The Turner's Falls Company owns a large tract of land available for manufacturing and other building sites, which it sells. Power is disposed of to manufacturers under a perpetual lease. The usual rate has been $7 50 (*b*) per annum per horse-power, rental reserved, but there is no established rate for the future. In the use of water no priority of rights is considered to exist, all the concerns standing on the same footing. The amounts used are determined by weir measurement in the tail-races, made as often as there is any change in the wheels run, or oftener at the option of the company. The greater part of the utilized power is in use night and day, being employed by paper-mills; and though there is, generally speaking, a large surplus power, yet, on account of the filling up on Sunday of a great many ponds on the various tributaries above, there is a slight scarcity of water here on Mondays during a dry season. There is a considerable pondage above the dam, extending 3 or 4 miles up stream, but mainly included within 3 miles. The power at this point has been developed gradually, and on account of the initial expense of extending the canal to the foot of the rapids, mills have been located close to the dam and from there down stream; in this way it happens that the fall is not utilized to the best advantage.

The interests of Turner's Falls as a manufacturing point have become solidly established, and its future growth seems to be assured. The village is distant by rail about 100 miles from Boston and 175 from New York. The precise plan to be adopted in further improving the power is stated not to have been fully decided upon. The first,

a Eleven feet is said to have been the greatest freshet depth noted on this dam.

b According to the president's report, June 13, 1871, some of the earliest leases were at rentals ranging from $5 to $7 50, and even $10, per horse-power.

or upper level, which constitutes the present canal, can be widened and extended, and, as will be seen, would thus render available a much larger fall than at present. Its widening would probably be expensive in the upper portion, on account of the rock to be cut through, but its extension and other work on the lower course would be easy, as it there enters upon a flat sandy plain. A second level may or may not be introduced. In time, if desirable, the wheel-pits near the dam will be sunk lower, and a tail-race run from them down stream so as to utilize the fall fully, instead of partially as now.

From the crest of the Turner's Falls dam to the crest of the Holyoke dam, according to the most reliable figures that are accessible, there is a fall of 75¼ feet. In an ordinary low stage Holyoke backwater extends to the vicinity of Hatfield. From that point up there are no rapids until we reach what are known as the "lower falls". These are about a mile and a half below the Turner's Falls dam, and the locality is also called the "stone dam", because a natural ledge here runs diagonally across the stream and causes an abrupt fall of several feet, said to be 7 feet. The right bank is succeeded by a small meadow shut in by high steep hills, which form the banks of the stream on that side, thence for a mile, more or less, to the Deerfield valley, where are wide flat meadows. The left bank rises steeply, and is composed apparently of a light sandy soil, to a height of 50 or 60 feet above the river, beyond which stretches a fine level plateau, continuous with that already described as lying along the lower course of the Turner's Falls canal. The privilege at the lower falls can probable best be utilized in connection with that owned by the Turner's Falls Company, by an extension of their canal system.

From the top of the Turner's Falls dam down to smooth water below the lower falls there is stated to be a fall of 62½ feet. Of this the Turner's Falls Company has already improved 41 feet; it also owns land along one side of the river covering 9 feet more; and the remaining 12½ feet is said to be owned by a party interested in that company. No gaugings on this part of the river having been learned of, the flow and power at this point are placed, by estimate, at the figures given below:

Estimate of total power available at Turner's Falls, Massachusetts.

Stage of river.	Drainage area.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Flow per second, average for the 24 hours.	Theoretical horse power. 1 foot fall.	41 feet fall.	50 feet fall.	62½ feet fall.	Effective horse-power utilized in 1880.
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*					
Low-water, dry year	6,902	10	12	11½	9	42½	3,100	352.16	14,440	17,610	22,010	4,320
Low-water, average year							3,500	397.60	16,300	19,880	24,850	
Available 10 months, average year							4,500	511.20	20,960	25,560	31,950	

TURNER'S FALLS TO BELLOWS FALLS.—From the top of the Turner's Falls dam to the foot of Bellows falls, a distance of about 50 miles, there is a rise of 61 feet, corresponding to an average slope of say 1.2 foot per mile. The stream runs nearly all this distance with smooth water, rapids occurring at but one or two points.

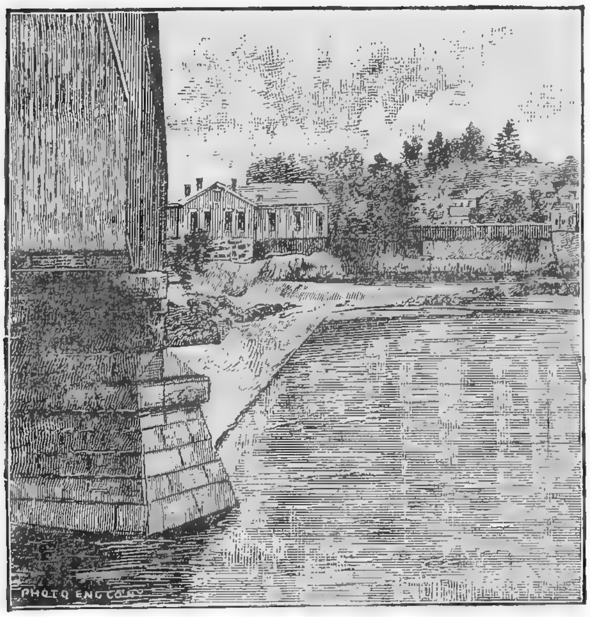
FIG. 18.—Dam at Bellows Falls.

Three and one-half or 4 miles above Turner's Falls, and about a third of a mile above the mouth of Miller's river, are what are known as the "French King" rapids. A ledge of rock runs diagonally in a broken line across the river, and large bowlders of conglomerate also appear in the bed. These rapids extend only a few hundred feet, and the fall in that distance cannot be more than 2 or 3 feet, with smooth water above and below. Below this vicinity, down to Miller's river, the banks appear firm, and are in places of solid rock. From the rapids down, the east bank rises high and steep, directly from the water; the opposite bank is less abrupt, but does not offer a favorable site for the large use of power.

Power at Bellows Falls.—At Bellows Falls the immediate valley is probably less than a mile wide and is inclosed by steep hills. The river here descends over a series of ledges and through a narrow gorge, where it is hemmed in by high walls of solid rock; between these it rushes down in falls and rapids, but reaching the foot of the gorge spreads out again in smooth water, resuming its characteristic appearance. A dam extends across at the head of the rapids, and a canal conveys water thence, at some distance from the river-bank, down to the foot of the falls, where are located the mills.

At the site of the dam the river contains huge outcropping ledges, between which the structure has been built in an irregular line projecting well up stream. The distance across in a straight line is 550 feet, but the actual

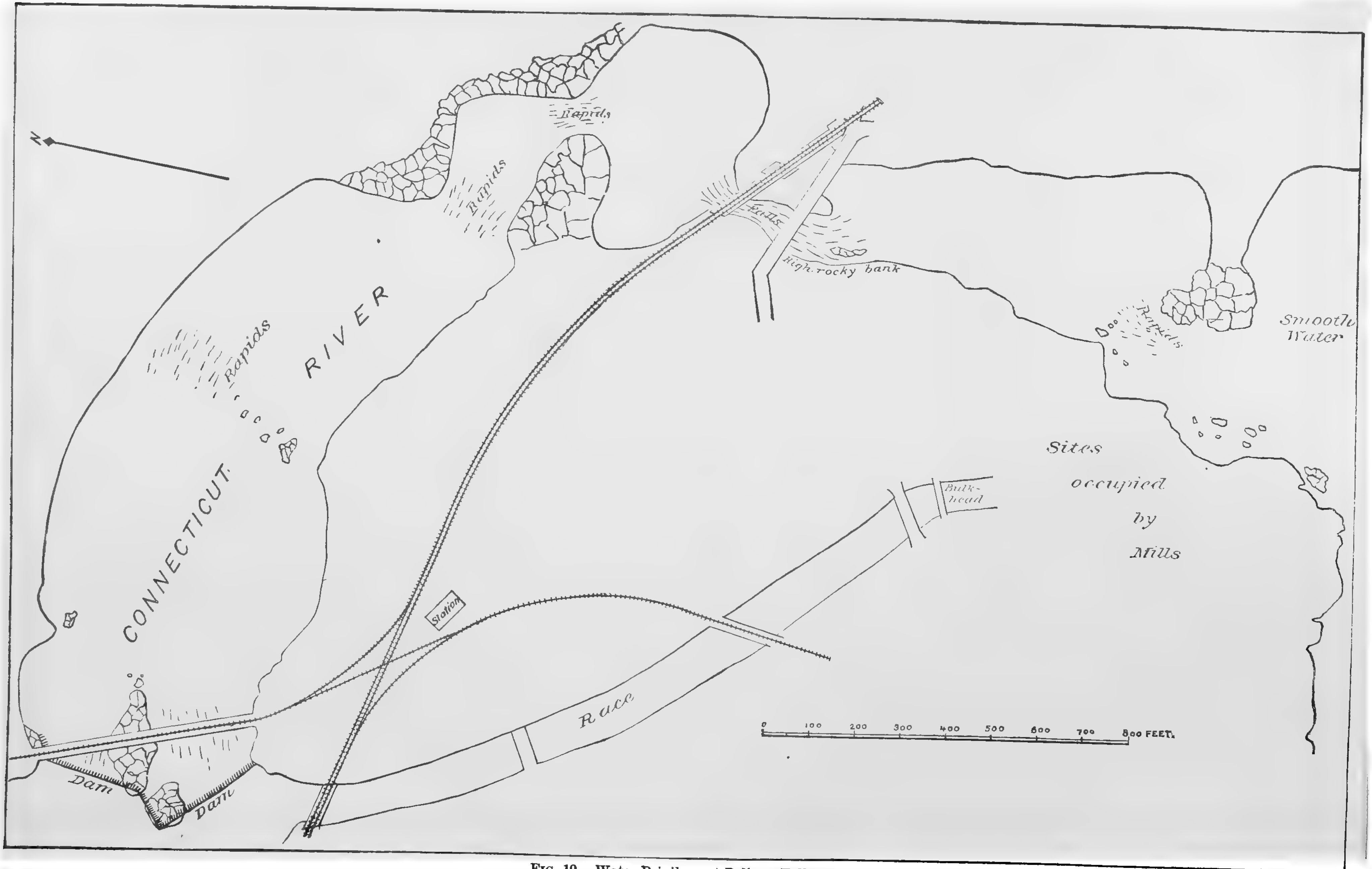

FIG. 19.—Water Privilege at Bellows Falls.

length of roll-way is probably as much as 600 feet. The iron bridge of the Sullivan County railroad spans the stream close to the dam, and its piers are founded upon the same ledges against which the latter abuts. The dam was originally built about 1795, but was rebuilt in 1869 at a cost stated to have been about $25,000. It is constructed of logs, rests throughout upon solid rock, to which it is firmly bolted down, and has natural rock abutments. The influence of slack-water from this dam is thought to extend at least 8 miles up the river.

The canal opens out a short distance from the end of the dam, and in its upper course has about 65 feet width of water-way. Before reaching the bulkhead, which is 1,500 feet from the entrance, it is an excavation in earth and is walled only to a small extent. At the first or upper bulkhead it narrows to about 30 feet and runs through a passage-way blasted in the solid rock. This bulkhead is of wood, and contains three gates, raised by a screw and cog-wheel arrangement, worked by a hand-wheel. A short distance beyond there is a second bulkhead, also of wood, and built in two sections at right angles with each other. The main canal here divides into two branches, which run short distances and in turn subdivide to convey water to the mills, which are close at hand. In certain improvements which are contemplated the upper bulkhead is to be entirely removed and the canal made as wide there as above. The lower bulkhead is to be replaced by a new structure of stone, in which there will be for each set of gates, *i. e.*, for each of the two branches of the canal, two openings 4 feet wide and two 8 feet wide, each opening to extend 10 feet below the water-surface.

The total fall from the top of the dam to smooth water below all the rapids is commonly given as from 52 to 54½ feet.(*a*) A fall of 22 feet is taken up from the main canal, or upper level, to the lower, and the balance thence to the river. Some of the mills draw from the upper level and discharge directly into the river, and in a number of cases the fall available at mills is not entirely utilized.

The water-privilege here is owned by the Bellows Falls Canal Company, which leases power to the various manufacturers. The nominal rate charged is $450 per annum per mill-power of 60 horse-power. No accurate measurements are made of the amounts of water used, but the quantities rated for the wheels are accepted in practice. In the fall of 1882 there were the following lessees of power:

Lessees of power at Bellows Falls, October, 1882.

Firm.	Manufacture, etc.	Production, etc.
Fall Mountain Paper Company	News and manila papers, and card middles	Employs 300 hands. Production, 25 tons per day.
Moore, Arms, & Thompson	Manila and other papers	Employ 80 hands. Production, 10 tons per day.
Willard Russell & Company	Wood-pulp and manila paper	Employ 27 hands. Production, 2½ tons of pulp and 4 tons of paper per day.
J. T. Moore	Tissue manila paper	Employs 11 hands. Production, from 1,200 to 1,500 pounds per day.
Flint & Fisher	Tissue and medium manila papers	Production, from 1 to 2 tons per day.
John Robertson & Son	do	Production, from 2,000 to 4,500 pounds per day.
Vermont Farm Machine Company	Various implements for dairy farming	Employs from 60 to 70 hands.
Bacon Brothers	Planing and sawing	
Osgood & Barker	Machinists	
Lucien Barbour	Picture-molding	
Adams	Grist-mill	

Several of the smaller powers are supplied by wheels put in by the canal company. Steam is not used for power at any of the mills; the water-supply is commonly sufficient, though for one week during the summer of 1882 it was necessary to shut down half of one mill. The various mills are built in very closely and irregularly upon a rocky slope, and though the firm foundations which they obtain are an advantage, still the location appears poorly suited by nature to the convenience of extensive manufacturing. On one occasion, at least, the river has risen so as to overflow the lower portion of this site. The ordinary rise, however, at the foot of the rapids is not excessive, and for the five years preceding 1882 had probably not exceeded 8 feet; a large mass of rock which obstructed the river there was being removed by blasting during the year mentioned, and an enlarged water-way will thus be afforded with less danger of overflow. Of the freshets in this part of the Connecticut river, those of 1862, 1869, and 1872 have been notable ones; during the heavy rains of September, 1882, there was a depth of 5 feet on the Bellows Falls dam. Surface-ice usually remains long enough above the dam to become thoroughly rotted. The ice in the canal breaks up every few days, and is then removed. There is very slight trouble from anchor-ice except in an open winter.

There is some vacant space still available for new mills, and the widening out of the canal at the upper bulkhead will permit a considerably increased supply of water at its foot. Following is an estimate of the power of the river at this privilege:

a This is somewhat greater than the figure previously given (49 feet) for the descent from the head to the foot of the falls, in the general table of elevations on the Connecticut river, as taken from Hitchcock's *Atlas of New Hampshire*. The disagreement may be due to the measurements having been made between slightly different limits, or not at the same stage of river.

Estimate of power at Bellows Falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.				
		Spring.	Summer.	Autumn.	Winter.	Year.						
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches*	*Cubic feet.*	*1 foot fall.*	*49 feet fall.*	*50 feet fall.*	*52 feet fall.*	*54½ feet fall.*
Low water, dry year (*a*)	5, 211	9½	11½	10½	8½	40	1, 950	221. 52	10, 850	11, 080	11, 520	12, 070
Low water, average year							2, 300	261. 28	12, 800	13, 060	13, 590	14, 240
Available 10 months, average year							3, 000	340. 80	16, 700	17, 040	17, 720	18, 570

a In extreme cases the power may sink somewhat lower than the figures here given, but in the very lowest stage of river the effective horse-power is stated by the president of the canal company not to fall below about 8,000.

NOTE.—Total effective horse-power utilized in 1880, as returned by enumerators, 4,210. Up to October, 1882, this amount had been increased, by the introduction of two new mills and increasing the power at the old ones, to 7,040 horse-power, of which 6,847 was employed in paper manufacture.

RIVER ABOVE BELLOWS FALLS.—*Sumner's or Quechee falls.*—This is the first water-privilege met in ascending above Bellows Falls, and is located 2 miles below the mouth of the Ottaquechee river, and 7 miles below White River Junction; it is owned by Messrs. Moses, D. H., and John C. Newton, all of Holyoke. There was formerly a dam 8 or 9 feet high at this point, by which a total fall of 13 feet was obtained; with obstructions removed, the available fall of the privilege would now be 15 feet. For 1,000 or 1,500 feet the river is full of ledges, which rise above the surface at many points, and among these it runs in a series of rapids, having thus a natural fall of 8 feet.

A division of the Central Vermont railroad runs along the west bank, which is high and steep. The east bank is rocky and of fair height, and is succeeded by a fine open stretch of comparatively level ground. The power is at present entirely unimproved, and no sign remains of the old dam, unless it be a short piece of rude crib-work next the west shore. It is said that the Messrs. Newton had made arrangements to build a new dam here, but that the opposition of a neighboring mill-owner, on a side stream above, who claimed that his privilege would be within reach of backwater from the proposed dam, interfered with carrying out the enterprise.

September 1, 1882, the volume of water at this locality, in a very low stage, was gauged and found to be 1,377 cubic feet per second. By estimate, the power to be obtained in different stages may be given as below:

Estimate of power at Sumner's falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.		
		Spring.	Summer.	Autumn.	Winter.	Year.				
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*1 foot fall.*	*13 feet fall.*	*15 feet fall.*
Low water, dry year	4, 234	9½	12	10½	8½	40½	1, 500	170. 40	2, 220	2, 560
Low water, average year							1, 800	204. 48	2, 660	3, 070
Available 10 months, average year							2, 350	266. 96	3, 470	4, 000

Olcott or White River falls.—Nine miles above Sumner's falls, and about 2 miles above White River Junction, is the Olcott Falls privilege, probably the best on the Connecticut river above Bellows Falls. It is said to be owned mainly, if not entirely, by Messrs. Wilder & Co., paper manufacturers, of Boston, and in October, 1882, was being developed by the Olcott Falls Company. A series of rapids and falls here extend for some distance down the river, while the west bank presents a fine level plain for mills and a village. At the time mentioned a substantial crib-work dam, located at the upper falls, was already far advanced in construction. It rests throughout upon ledge rock, to which it is bolted down, and the logs are also bolted together at each intersection. The dam runs in a long curve diagonally across the river, with a roll-way about 600 feet in length. It was designed to have a height in midstream of 18 or 20 feet, and a corresponding base of 54 or 55 feet, but these dimensions decrease as the dam runs in on the ledges. The structure has a long back-slope covered with 4-inch hemlock planking, while the crest is protected by boiler-iron. The face of the dam slopes down stream from the crest a short distance, and then drops off vertically.

The crib-work consists of hemlock logs ranging from 10 to 16 inches in diameter. The logs were first sawed so as to give two parallel faces, each log being sawed to its best advantage, and selection was made from these so that timbers of uniform thickness came in the same layer. When completed the dam was to contain over 1,000,000 feet of timber.

On the east bank there is a natural rock abutment. At the west end of the dam there were being constructed an artificial abutment and bulkhead of granite masonry rising 9 feet above the top of the dam. The bulkhead was designed to be 27 feet wide with the current, and to contain eight gate-openings, each 8 feet wide in the clear; these were to connect with a canal about 80 feet wide, running thence to the level ground before mentioned.

The fall on this privilege is 35 feet. It is stated by Messrs. Wilder & Co. that they intend to use a portion of the power in the manufacture of wood-pulp and paper, probably with works of a capacity for 10 tons of each per day. They estimate that they will have from 3,000 to 5,000 horse-power surplus to dispose of, with all the land necessary. A spur-track from the Passumpsic railroad will run directly to the grounds. The privilege is an

excellent one, though as there is now no settlement at the locality, a village will have to be built up. The measurements of flow made by Professor Fletcher at Hanover, a couple of miles above, and already given in the introductory remarks on the river, will serve as a guide to the volume that may be depended on at certain stages of water. For low water of dry and average years, and for the amount available ten months in average years, the volume and corresponding theoretical horse-power are here estimated at the following figures:

Estimated volume and power of the Connecticut river at Olcott falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.	
		Spring.	Summer.	Autumn.	Winter.	Year.			
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*1 foot fall.*	*35 feet fall.*
Low water, dry year	3,373	9½	12	10½	8½	40½	1,100	124.96	4,370
Low water, average year							1,400	159.04	5,570
Available 10 months, average year							1,800	204.48	7,160

Passing above Olcott falls there are no shoals worth mentioning below Dodge's falls. Between the villages of Woodsville and Wells River the stream is narrow, and has a rocky bed with high rocky banks, and it is said that the plan has been considered of building a dam there 10 or 12 feet high, and running a canal to a flat a short distance below. There is no shoal at this point, and a fall only equal to the lift of the dam could be obtained. From here up to Dodge's falls the banks are of good height, and in places rocky. At intervals they are succeeded by level plateaus stretching back from the river, while at other points the hills rise at once on either side from the water.

Dodge's falls.—These are 4¼ miles by river above Wells River. Rapids here continue for 1,000 or 1,500 feet, with two principal pitches a few hundred feet apart. In the narrow part of the rapids the width between banks is perhaps 350 feet. The stream is full of rocky reefs, rising here and there a few feet above the water. The banks are of good height, and for 10 or 15 feet above low water are of solid ledge. Below the falls the east bank is high and abrupt, but on the west side there is a wide level tract of land. The location is good, the railroad being close at hand, and there is a fine site for a secure dam.

According to a table previously given, the descent from the foot of McIndoe's falls, the next above, down to Wells River, a distance of about 7 miles, is 25 feet. The pocket-level indicates a total fall on the rapids of 12 or 15 feet. The privilege is owned by Mr. George Van Dyke, of McIndoe's Falls, and was formerly used by a saw-mill, but the mill and dam are said to have been carried away in a freshet a few years ago. It is claimed by Mr. Van Dyke that a dam 12 feet high can be built on the site of the old one, somewhat above the foot of the falls, without injury to the privilege above.

Estimate of power at Dodge's falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.		
		Spring.	Summer.	Autumn.	Winter.	Year.				
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*1 foot fall.*	*12 feet fall.*	*15 feet fall.*
Low water, dry year	2,219	9	12	10½	8½	40	650	73.84	890	1,110
Low water, average year							850	96.56	1,160	1,450
Available 10 months, average year							1,150	130.64	1,570	1,960

McIndoe's Falls.—The power at the west end of the dam is owned by the creditors of R. E. Peabody, of Saint Johnsbury, Vermont, but is leased by George Van Dyke, who runs a large saw-mill here, at which 10,000,000 or 12,000,000 feet of lumber are sawed annually. The dam is an old and not very tight structure of logs, extending out from either shore to an outcropping ledge in the center of the river; the fall is 12 feet. Van Dyke has wheels of from 300 to 400 horse-power capacity, and with a good dam would have surplus water at the lowest stage of the river. On the east side of the river the power is owned by Messrs. Hadlock & Willey, who operate a grist-mill with about five runs of stone.

Estimate of power at McIndoe's Falls.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*12 feet fall.*	
Low water, dry year	2,205	650	73.84	890	350–450 (?)
Low water, average year		850	96.56	1,160	
Available 10 months, average year		1,150	130.64	1,570	

Barnet bridge.—Passing up stream, the next fall is close by Barnet bridge, where there is an abrupt pitch of about 4 feet. The stream narrows to a low-water width of 50 feet under the bridge, and flows between high steep rocky banks. The natural site for a secure dam is fine, and there is good building-ground just below on the east side, but there are several features which probably deprive the privilege of practical value. The freshet-rise in so contracted a place is great, and in extreme cases reaches the railroad track which runs along the west bank and below the falls is 17 feet above low water. It would not therefore answer to raise the river here with the railroad as at present. Above the falls are extensive low meadows which would be overflowed if a dam were built, and it is probable also that a dam of much height would cause backwater at the East Barnet privilege on the Passumpsic.

Summary of water-privileges on the Connecticut river below the Passumpsic river.

Locality.	Drainage area.	Fall used or available.	Theoretical horse-power, average for the twenty-four hours.			Effective horse-power utilized.	Remarks.
			Low water, dry year.	Low water, average year.	Available ten months, average year.		
	Sq. miles.	*Feet.*					
McIndoe's Falls	2, 205	12	890	1, 160	1, 570	350–450	Power used by 5-run grist-mill, and large saw-mill turning out 10,000,000 to 12,000,000 feet of lumber annually.
Dodge's falls	2, 219	12	890	1, 160	1, 570	....	Power formerly used by saw-mill, but dam is now gone, and the privilege is entirely unoccupied.
Olcott falls	3, 373	35	4, 370	5, 570	7, 160	....	A splendid power, recently developed by Wilder & Co., of Boston. They will erect extensive works for the manufacture of pulp and paper, and will have a large surplus power for disposal.
Sumner's falls	4, 234	15	2, 560	3, 070	4, 000	....	A fine privilege, but entirely unimproved. Owned by the Messrs. Newton, of Holyoke.
Bellows Falls	5, 211	*a* 52	11, 520	13, 590	17, 720	7, 040	Power largely employed, mainly in the manufacture of paper. See description.
Turner's Falls	6, 902	*b* 62½	22, 010	24, 850	31, 950	4, 320	See description.
Holyoke	8, 006	59	25, 470	27, 480	35, 190	15, 000±	Do.
Windsor Locks	9, 347	*a* 30	15, 500	16, 700	21, 130	1, 800–1, 900	Do.
Total at above falls	....	277½	83, 210	93, 580	120, 290	28, 500±	
Total effective power available, assuming an efficiency of 80 per cent	....	....	66, 570	74, 860	96, 230	....	
Total effective power available, assuming an efficiency of 60 per cent	....	....	49, 930	56, 150	72, 170	....	

a Approximately. *b* Only 41 feet thus far developed.

Fifteen-Mile falls.—These falls begin shortly above the mouth of the Passumpsic, and are said to continue substantially unbroken to Dalton, the rise in this distance amounting to nearly 400 feet. Near the junction with the Passumpsic the Connecticut river runs in a wide open valley and is bordered by low meadows. Its bed is there gravelly, its banks are low, and there is a moderately rapid current. Both rivers have worn several channels across these meadows, by which their waters are dispersed and form islands.

Two or 3 miles farther up stream, near Mulligan's mill, which is on a little tributary brook, the main river was found to be full of rapids, the bed gravelly, and apparently ledgy at points. The west bank is there of good height and is composed of solid rock; the east bank rises high and steep and is sandy. Except for this latter feature the locality would afford a splendid site for power, the west bank being very favorable for buildings and a canal. A very good pondage could be obtained over poor land. At Lower Waterford bridge the river is 275 or 300 feet wide, and flows in rapids over a gravelly bed. The banks are high and composed of gravelly soil.

It may be said in general of the section between Barnet and Lower Waterford that the country is sparsely settled and but little cultivated. Corn and grass seem to be the principal productions, while to the south of Barnet considerable land is devoted to sheep-pasturage. Very little meadow-land is to be seen along this part of the river, and at times the valley is narrow and deep with steep side slopes. The adjoining country rises to high hills with generally rounded outlines, though rocky and precipitous in places. The most noticeable feature from the river valley is the extent to which the timber has been cut away, the hills appearing much more bare than 200 miles farther south; what trees do remain are of young growth. A short distance above Barnet the Passumpsic railroad leaves the main river and follows up the valley of the Passumpsic. The immediate valley of the Connecticut is then without any railroad throughout the length of the Fifteen-Mile falls; but from their head, near Dalton, the Boston, Concord, Montreal, and White Mountains railroad and the Grand Trunk railway follow the river, in the order named, for about 25 miles, above which it is distant from any line.

The examination of the Connecticut river did not extend above Lower Waterford, but the upper course has been described by Dr. C. H. Hitchcock, in the *Geology of New Hampshire*, and the liberty will be taken of quoting from the account there given. Writing of the surface features of the surrounding region, Dr. Hitchcock

states that "the extreme northern part of New Hampshire is covered by a continuous primeval forest, and the surface of the country is broken by undulating ridges which here and there rise to mountain heights". The northern basin of the Connecticut river in Vermont is of similar character to that in New Hampshire. The statement which has been quoted was made eight or ten years ago, and since that time serious inroads have yearly been made upon the forests of this section, though they have not yet been sufficient materially to alter the general proportion of timber.

The extreme source of the Connecticut river is in the Third lake, or lake Sophy, which lies within half a mile of the Canada border. Four miles to the south it reaches the Second lake, which is of considerably larger size. Five miles in an easterly direction from Second lake the water-shed of the Connecticut river just touches the boundary of Maine. The Second lake and the course of the river below are thus described by Dr. Hitchcock:

> This lake is 2¾ miles in length, and in the widest part it is little more than a mile, and the height above the sea is 1,882 feet. Its area is about 1⅝ square mile. It is one of the most beautiful of our northern lakes. The graceful contour of its shores, the symmetry of its projecting points, the stately growth of its primeval forests, the carpet of green that is spread along its border and extends through the long vista of the woods, the receding hills and the distant mountains, present a combination of the wild, the grand, and the beautiful that is rarely seen. Near its northern border, besides the Connecticut, it receives two tributaries, one from the northeast and one from the northwest.
>
> Its outlet is on the west side, near its southern limit; it is 40 feet in width and has a depth of 18 inches. Twenty rods from the lake it has a fall of 18 feet or more; then its descent is quite gradual, but forms here and there deep eddies. A mile from the lake it becomes more rapid, and rushes down between precipitous walls of rock in a series of wild cascades, which continue for half a mile. It receives two tributaries from the west before it flows into Connecticut lake. Here we find a sheet of water exceedingly irregular in its outline. Its length is 4 miles, and its greatest width 2¾, and it contains not far from 3 square miles. * * * On the west shore of this lake the country is settled, and the grassy pastures extend down to its border; but for the most part it is still surrounded by a primeval forest. * * * The water at the outlet flows over a rocky barrier, the stream falling abruptly nearly 37 feet. The fall is quite rapid for 2½ miles; then the flow is more gentle for about 4 miles; then it becomes more rapid again, and continues thus until after it passes West Stewartstown. It is then nowhere a sluggish stream, and has rapids in many places until it gets below the falls of Northumberland; then it is the most placid of streams until it reaches the Fifteen-Mile falls, which begin in Dalton.

The country along the Connecticut above Hall's stream is moderately hilly, but not rugged, and in 1874 more than nine-tenths was still covered with the original forest. Thence to the head of the Fifteen-Mile falls are fertile intervales, varying from half a mile to a mile in width. The surface back from the immediate river valley rises in bold hills and mountains.

Regarding the use of power on this extreme upper section of the river but little information can here be given, and that was mainly derived from correspondence. Above McIndoe's Falls there is no dam until we reach Guildhall, where 10 feet fall and 120 horse-power are in use at a saw-mill.

The next power is at West Stewartstown, about 80 miles by river above McIndoe's Falls. The dam is a wooden structure about 200 feet long and 10 feet high, and was built fifty years or more ago. Ten feet head and 100 horse-power are used for a saw-, grist-, and starch-mill, and it is stated that no additional power could be run, except in spring and fall. Where flowing freely the river has in that vicinity an average width of about 150 feet, with a summer depth of 2 and a winter depth of 3 feet.

Mr. W. F. Allen, proprietor of the saw-mill at West Stewarstown, wrote, in 1880, that there were thirteen dams above him on the Connecticut, having an average fall of 9 feet; and that there were dams at the outlet of both the First and Second Connecticut lakes, the former capable of being raised 12 feet and the latter 8 feet. Probably these dams at the headwaters are utilized mainly for the purposes of log-driving.

Drainage areas of the upper Connecticut river.

Locality.	Square miles.
At outlet of Second lake	47
At outlet of Connecticut lake	93
Below the mouth of the Nulhegan river	794
Below the mouth of the upper Ammonoosuc river	1,176
At Dalton	1,431
Below the mouth of the Passumpsic river	2,139

TRIBUTARIES OF THE CONNECTICUT RIVER.

From the hills, and even mountains, which rise higher and higher as we depart from the immediate valley of the Connecticut, numerous swift-running streams, frequently broken by rapids and falls, flow down to the main river, and, being sustained by springs, lakes, ponds, and artificial reservoirs, furnish valuable water-powers which are largely utilized. Some of the more important of these streams will be described, beginning toward the mouth of

the Connecticut, and taking up, in order, Salmon, Hockanum, Farmington, Scantic, Westfield, Chicopee, Mill, Deerfield, and Miller's rivers, and, in less detail, some of the tributaries received in New Hampshire and Vermont, the names and drainage areas of which are included in the list given below:

Principal tributaries of the Connecticut river.

Name.	Lies on which side of main stream.	Lies in what state.	Drainage area.	Name.	Lies on which side of main stream.	Lies in what state.	Drainage area.
			Sq. miles.				*Sq. miles.*
Perry stream	North	New Hampshire	27	Black river	West	Vermont	152
Indian stream	do	do	67	Williams river	do	do	103
Hall's stream	do	New Hampshire and Canada.	88	West river	do	do	363
Nulhegan river	West	Vermont	132	Ashuelot river	East	New Hampshire	422
Upper Ammonoosuc river	East	New Hampshire	252	Miller's river	do	Massachusetts	396
Israel's river	do	do	129	Deerfield river	West	Vermont and Massachusetts.	646
John's river	do	do	86	Mill river	do	Massachusetts	58
Passumpsic river	West	Vermont	485	Chicopee river	East	do	706
Wells river	do	do	94	Westfield river	West	do	514
Lower Ammonoosuc river	East	New Hampshire	388	Scantic river	East	Massachusetts and Connecticut.	118
Wait's river	West	Vermont	156	Farmington river	West	Connecticut	584
Ompomponoosuc river	do	do	123	Little river	do	do	76
White river	do	do	623	Hockanum river	East	do	79
Mascomy river	East	New Hampshire	190	Salmon river	do	do	150
Ottaquechee river	West	Vermont	192				
Sugar river	East	New Hampshire	272				

THE SALMON RIVER.

The main portion of this stream is formed in the western part of the town of Colchester, Connecticut, by the union of Black Ledge river and Salmon brook. It runs thence southwesterly and southerly a distance of 9 or 10 miles to the Connecticut, forming the boundary between the towns of East Haddam on the one hand, and Chatham and Haddam on the other, and empties at East Haddam Landing. Its basin comprises 150 square miles.

The river has not been much developed, but it is looked upon with great favor by those using it, and would admit of considerable improvement and further use. It drains a hilly section, thickly timbered and having small agricultural value. The immediate valley is, as a rule, narrow and deep; toward the mouth, though, it opens out, and the river is bordered by low lands subject to overflow. During eight months in the year a small steamer can ascend about 2 miles from the mouth, or to within a mile or so of Leesville. This route is said to be used generally by the merchants for freighting, and will be by the Moodus manufacturers whenever it becomes possible to ship directly to New York by this channel. At present the Leesville factory sends merchandise by team to Goodspeed's Landing, while the mill at Comstock's Bridge, a few miles above, ships by the Air Line railroad from Lyman Viaduct. The bed of the river at Leesville and above is either ledge rock, or gravel underlaid by ledge rock at a slight depth; granite and mica schist are the prevailing varieties. The banks are gravelly. Below Leesville the stream is under the influence of backwater from the Connecticut, but above that point it has a pretty steady fall, and is mainly made up of shoals. At Comstock's Bridge the width is 50 feet, and at Leesville about 90 feet.

Since Pine brook and Moodus river both enter the Salmon below the lowest water-privilege, the reservoirs on those important little streams are no help to manufacturing on the main stream, and the latter really receives but moderate assistance from any reservoirs. The only ones draining into its upper course are as follows:

1. North pond, on the line between Hebron and Lebanon, is estimated to contain 200 acres, but measures 244 acres upon Clark & Tackabury's map of the state (1859). It is fed almost entirely by springs, can be drawn down 10 feet from full-water line, and usually fills, though it did not do so for the two years prior to the fall of 1882. There is no wastage, and the supply could not therefore be substantially increased by raising the dam. The reservoir is controlled by A. G. Turner.

2. Marlborough pond is controlled by H. A. Blakeslee, of Hartford. It is described as being nearly a mile long and about a third of a mile wide. It can be drawn down 9 feet from full-water line to the bottom of the gate, and after leaving the lake the water falls 52 feet within a short distance. The pond fills regularly every spring, and keeps well filled during the entire year, its supply being largely from springs. It is thought that the surface might be raised 3 or 4 feet higher at no great outlay.

3. Whitmore's reservoir, in the town of Colchester.

It is claimed on Salmon river that these reservoirs, as they are now operated, are of not much assistance to the stream in the dry season. There was formerly a paper-mill on the outlet of Whitmore's reservoir, but it has been removed, and the reservoir now acts only as a natural pond. There are also stated to be mills at the outlets of North and Marlborough ponds; consequently these ponds, being drawn down upon for more or less continuous use, cannot be managed strictly as storage reservoirs, and are not therefore of the benefit they might otherwise be to the main stream. Manufacturers on the latter consider, however, that new storage reservoirs might conveniently be built, and that the low-water flow might thereby be doubled, or even trebled. The stream drains a considerable area, receives many tributary brooks supplied by springs, and the valleys are favorable to storage, exhibiting, as the eastern Connecticut streams generally do, frequent intervales shut in on all sides by hills. The water of the stream is very clear and pure.

As it now is, Salmon river is subject to considerable fluctuations in volume, and rises rapidly after rains. In the highest freshet observed at Comstock's Bridge the water poured over the 250-foot roll-way 8 feet deep. The ordinary spring-freshet rise on this dam is about 4 feet, and in the river below the Leesville dam 6 feet is looked upon as a heavy rise. There is a large run of cake-ice down stream in spring, but usually sufficient depth of water on the dams to carry it over without injury to them. The ice sometimes gorges in the narrows and causes backwater. At Comstock's Bridge this has been sufficient to hide the dam completely from sight, though the gorges last but a short time. They also form below Leesville, and cause some backwater there for perhaps half an hour at a time. But, generally speaking, backwater is not considered a serious hinderance on this river. The Leesville mill has been known to stop a day from that cause but not a minute, even, during the five years preceding 1882.

At the village just mentioned the first power met in ascending the stream is in use by the East Haddam Duck Company, running 1,080 spindles. The river-bed is at this point solid ledge rock. The dam rests upon that foundation, and is a framed structure having three rows of vertical braces. The roll-way is 120 feet long, 12 feet high, and is supplemented by a gravel embankment. There is a considerable amount of leakage through the dam. The ponds set back a mile or a mile and a half, and is alone sufficient to run the mill for a day. Water is brought 225 feet to the mill through a wooden tube. This is made of 2½-inch white pine, is 54 inches in internal diameter, and is secured by ¾-inch round-iron hoops at intervals of 15 inches. The tube showed no leakage whatever. The fall at the mill is 17½ feet, and the rated wheel capacity 70 horse-power. It is stated that in ordinary years this can be realized throughout, with a waste over the dam nearly all the time, but in extraordinarily dry seasons, such as prevailed in the years 1880–'82, there is some scarcity of water, though the effective horse-power is estimated never to run below 50.

From Leesville up to Comstock's Bridge, a distance by river of 3¼ miles, the traveled road runs high up on the side of the valley, which is much of the way very narrow and deep. Though a mill-site could probably be found, it would not be very easily accessible, nor would there be good opportunity for much of a village.

The privilege at Comstock's Bridge is occupied by Brown Brothers, manufacturers of card paper. They have a stone dam, raised 2 feet on top by a wood addition. The roll-way is 250 feet long and 7 feet high. Water is brought to the mill 50 or 60 rods in a race. The fall is 16 feet, and 100 horse-power is used twenty-four hours in the day. In an average year this can be obtained for about eleven months, but in an exceptionally dry season the power sinks as low as 30 horse-power, which is considered the minimum. In ordinary years there is a large waste over the dam for eight months.

The stream was not examined above this point, but there were reported to be another paper-mill and a grist-mill within 3 miles. There is some unimproved fall on this part of the stream, though no data are accessible showing accurately its amount. The manager of the Leesville mill estimated the rise to be from 15 to 20 feet between that point and Comstock's Bridge, and at the latter point it was thought that a good privilege might be secured within half a mile either above or below, and with a very considerable pondage in one case. The theoretical power of the stream there may be estimated as below:

Estimated flow and power at Comstock's Bridge.

Stage of river.	Drainage area.	Average flow per second for the 24 hours.	Theoretical horse-power per foot fall.
	Sq. miles.	*Cu. feet.*	
Low water, average year	103	35	3.98
Available 10 months, average year		55	6.25

NOTE.—Average rainfall on basin, 11 inches in spring, 14½ in summer, 10½ in autumn, 12 in winter, and 48 for the year.

Salmon river receives in its lower course two important little tributaries, known as Moodus river and Pine brook.

Moodus river flows from the east through the town of East Haddam, and is but a few miles in length, measured to its extreme source. Bashan and another small brook unite some distance above the village of Moodus to form Meadow brook, and this, from a point about a mile and a half above the village, is called Moodus river. This stream drains a hilly wooded district well supplied with springs.. Its bed is rocky, the stone being rather soft and of no value for building dams or mills. The principal variety of timber found near is chestnut, with some hickory, oak, and maple. The descent of the stream is rapid, amounting to 350 feet or more in about 2 miles. The hills shed water freely and there is a quick rise after rains. The flow is, nevertheless, well sustained in summer, being supplied by two completed reservoirs, as follows:

1. Bashan pond, a natural lake raised by a dam. It covers about 300 acres when full, and can be drawn the equivalent of 220 acres to an average depth of 14 feet. If drawn down to the utmost it does not ordinarily fill up again in a single season; indeed, it has only been full twice since it has been used as a reservoir. It receives no tributary streams of any importance.

2. Fall Brook reservoir drains through Fall brook into the main stream about a mile and a half above Moodus. It is much smaller than Bashan pond, but furnishes a good supply of water and fills regularly, the brook running into it from above. It is estimated to flow about 140 acres when full, and can be drawn down the equivalent of 100 acres to an average depth of 5 feet.

These reservoirs are some little distance away from the mills, on side streams, and the water being allowed to run steadily from them, night and day, during the dry season, there is considerable wastage, the mill-ponds having very little capacity for storage. It is said that on opening the gates it takes three days for water from Bashan pond to reach Moodus in sufficient quantity to be of any avail, as much is in the intervening distance soaked up by the ground and retained in swamps and other low places.

The reservoir capacity can yet be largely increased, and it is estimated that the low-water volume of the stream even now can be doubled. In September, 1882, there was in process of construction a new storage-reservoir a mile and a half above the village of Moodus. It lies directly upon the main stream, to which it will prove a great help. The dam at its outlet was designed to have a roll-way 135 feet long, and to be built upon the site previously occupied by a very low dam which raised the stream perhaps 3 feet. It will be raised at present 5 feet above the old dam, and will give a flowage of 328 acres to a shallow depth. A storage of 40,000,000 cubic feet will thus be obtained, which is estimated sufficient to maintain the supply at the mills for six weeks during summer. The total expense of the improvement, including damages for flowage, is placed at $12,000. Being just above the mills, this reservoir can be easily controlled, and will permit a very economical use of the water of the stream. It is stated that the stream can be raised, in all, 15 feet at this point above its natural surface. By raising the reservoir surface 5 feet still higher than at present contemplated, a total flowage of 448 acres can be obtained, and a corresponding storage of 120,000,000 cubic feet. Without the assistance of the new reservoir, the ordinary spring flow of the stream, when not wasting at the upper reservoirs, has been found to be about 38 cubic feet per second at Moodus. All three of the reservoirs which have been mentioned are owned by an association composed of the various mill-owners benefited.

The manufacturing on this stream is mainly in the village of Moodus, but is scattered along 2 miles of its course. The mills are rather small, and of the thirteen, all but three make seine-twine; two establishments manufacture duck, and one, the Moodus Yarn Company, makes yarns and threads. The goods are mostly sent to New York, being shipped by team to Goodspeed's Landing, and thence by water during the period of steamboat navigation. The traffic thus brought about by the manufacturing on this mere brook is quite large, and Goodspeed's Landing is said to rank next after Hartford and Middletown in importance as a shipping point on the river.

The dams on the stream are in some cases stone, and in others framed; they probably average 50 feet in length of roll-way. Water is carried to the mills in races of moderate length. The falls used are large, but turbine wheels are employed except at the Williams Duck Company, where there is a breast-wheel. The wheels are stated, however, to be generally of old patterns and wasteful of water. Owing to this waste, and to that arising from the manner in which it is found necessary to manage the old reservoirs, the stream is not economically used. Still it is a good little stream for power, and is so considered by those using it. Hitherto the mills have been stopped about a month in summer by low water, but with the new reservoir completed it is expected that they will run steadily through that season. It is estimated by good authority that the wheels now employed in the village have a total of about 800 horse-power. The Moodus Yarn Company is the only concern employing steam for power at all; it uses steam all the time, but with new water-wheels can probably dispense with it.

Statistics of manufacturing at Moodus in August, 1882.

[Furnished by Mr. Greene, of the Moodus Yarn Company.]

Firms in order below new reservoir (no mills above).	Manufacture.	Fall.	Number of spindles.	Production per week in finished goods.
		Feet.		*Pounds.*
New York Net & Twine Company		68	2,160	5,000
Atlantic Duck Company		36	1,798	5,500
Williams Duck Company		23	1,280	4,500
A. E. Purple	Seine-twine	19	1,424	3,200
J. O. Cone	Saw-mill	12		
W. L. Fowler, jr.	Seine-twine	20	728	2,100
New York Net & Twine Company		21	1,184	3,800
Brownell & Co.	Seine-twine	20	1,152	3,000
H. Boies	Twine and yarns	24	1,600	4,000
A. E. Purple	Seine-twine	16	1,216	2,400
Moodus Yarn Company		42½	5,496	6,800
E. Johnson	Seine-twine	20	1,024	2,500
Do	do	25	1,024	2,600
		346½	19,986	45,400

The fall on the stream is practically all taken up. A few feet remain here and there, but not enough to constitute separate privileges.

Pine brook enters Salmon river from the north, near its mouth, heading in and deriving an important supply from Pokatopaugh lake, which lies in the town of Chatham. It is stated that the fall from the lake to the mouth of the stream, as determined by actual survey, is 460 feet in a distance of not over 7 miles. The lake is a natural sheet of water, the surface of which has been raised a little by a low dam. It is not known to have been recently surveyed, but is estimated by two or three manufacturers familiar with it to cover 800 or 900 acres. On the old state map which has been employed it measures 475 acres, but may not be correctly shown there. It receives no important tributaries, but seems to be largely fed from hidden springs. It is quite deep, probably 40 feet in places, and consequently a great part of the water cannot be drawn out. The Bevin Brothers Manufacturing Company owns the land at the outlet and controls the gates. From high-water mark the lake can be drawn down 6 or 8 feet. At an estimated expense of $2,000 the bottom can be dredged near the outlet and the gates lowered 4 feet; or at the same expense the pond can be raised 2 feet above present full-water mark. It would indeed admit of being raised a number of feet higher still, but it is thought that it could not be depended upon to fill more than the 2 feet mentioned. Two years ago, with the dam as at present, the lake did not fill, but it commonly does, and for two months or more water runs to waste.

The lake holds back freshets and ice. Its waters are very clear and pure, and Pine brook, which they supply, is regarded very highly by the manufacturers upon its course as a source of power, not so much from its size, which is small, as from its permanency. The Gong Bell Company's works have not been compelled to stop a single day in thirty years for lack of water. It is estimated that, with the lake full, the stream, under 20 feet head, will supply 35 effective horse-power throughout the year. The dams are short, and in most cases rude and cheap. Water is commonly conducted to the water-wheels through wooden flumes. The wheels are, with one exception, all turbines.

The manufacturing on Pine brook is almost entirely confined to the village of East Hampton, which is at the outlet of the lake; it is a place of about 700 inhabitants, located on the Air Line division of the New York, New Haven, and Hartford railroad. It is interesting to notice how, in passing from one small stream to another, we come upon industries the productions of which are familiar to every one, but the locations of which are known to but comparatively few. We also have frequent illustration of the tendency of members of a single trade to congregate. The chief enterprise at East Hampton is the manufacture of bells of all kinds, the yearly production of which has been estimated (in 1874) to exceed in number 25,000,000; in the particular industry of making sleigh-bells this point is claimed to be the most important in the United States. The first sleigh-bells ever made in this country were produced by William Barton, who in 1808 came from New York to East Hampton and engaged in their manufacture; he was the first man to cast sleigh-bells whole in their present form, and the first to turn them in a lathe. This branch of industry has continued to flourish, and there are now six bell-manufacturing concerns in the village.

The water-privilege nearest the lake was once occupied by a forge, where it is said that cannon-balls were made during the Revolutionary war.

Principal water-privileges on the outlet of Pokatopaugh lake.

Title of firm or privilege (in order from lake).	Manufacture.	Fall.	Remarks.
Above the village.		*Feet.*	
Old Forge privilege		12	Unoccupied.
Buell & Veazey privilege		7	Do.
Stewart D. Parmelee privilege		8	Do.
Bevin Brothers Manufacturing Company	Bells	12	
Merrick & Conant Manufacturing Company	Thread and silk	20	
Starr Brothers Bell Company	Bells	12	
Do	do	7	
East Hampton Bell Company Gong Bell Manufacturing Company	do	19	
D. W. Watrous & Co	Bells and coffin-trimmings	7	
D. B. Niles & Sons' privilege		15	Unoccupied.
William E. Barton privilege		14	Unoccupied; mill burned.
Barton Bell Company	Bells	16	
Henry Skinner	Saw- and grist-mill	20	
Sexton privilege		7	Unoccupied.
H. B. Brown & Co	Bolt-cutting machines	12	
Below the village.			
Old gun-shop privilege	In use for some kind of manufacturing.	60	
Pine Brook Duck Company's privilege	do	30	
Wetherell privilege	do	30	
House's paper-mill	Paper	30	
Total		339	

NOTE.—The facts concerning these privileges are as stated by a manufacturer long familiar with the stream; they are undoubtedly correct in the main, although the falls may not have been given with exactness in all cases.

It will be seen from this list that there are several privileges unoccupied. The falls as given foot up 339 feet, or about 120 feet less than the total descent of the stream from the lake. There is said to be considerable undeveloped fall on the lower part of the stream, and especially on J. S. Markham's property, below H. B. Brown & Co.

THE HOCKANUM RIVER.

This important little manufacturing stream has its principal source in Shenipsit lake, which lies on the boundary between the towns of Tolland and Ellington, Connecticut. It flows thence through portions of the towns of Vernon, Ellington, Manchester, and East Hartford, running in a southwesterly course, and empties into the Connecticut opposite Hartford; it measures 18 or 20 miles in length below the lake.

Shenipsit lake is a natural pond raised by an embankment having a stone roll-way about 50 feet long. It flows 680 acres, and can be drawn down from a full stage about 23 feet at the gates. The drainage area above the outlet is 15.4 square miles. Such an extent of country of course furnishes a great amount of surface water, but the reservoir is also largely fed by hidden springs. Probably two years out of three it fills up in spring, with a little wastage at the dam for a short time; but although the latter would admit of being raised still further, it is probable that the storage could not be substantially increased over its present amount. This reservoir is owned and controlled by the Rockville Water Power Company, an association of which nearly or quite all the Rockville mill-owners are members. The Rock Manufacturing Company is perhaps the largest user of power in the village, and sufficient water is drawn from the lake to run the wheel at one of its privileges. The amount thus supplied is about 60 cubic feet per second. The lake is drawn upon throughout the year, and the amount of water stated can always be obtained, the supply having run short but once in ten years. This stream was visited August 30, 1882, and although there had been no rain whatever since July 5, there were still remaining 21 feet of water in the reservoir. A very permanent and valuable water-power is furnished along the course of the stream below, which is also freed from freshets of importance.

After leaving Shenipsit lake the Hockanum river flows down through the village of Rockville in a narrow rocky valley among high hills. It then enters upon a more open country diversified by low hills, but showing some broad stretches of comparatively level land. Tobacco is in this section the principal crop, more or less corn, potatoes, and grass also being raised. Through this portion of its course the fall in the stream is moderate, and the banks are either gravelly or soft. For a mile below Adams' paper-mill, at Manchester, the bed contains much quicksand; but for a mile below that stretch, to and including the Burnside privileges, it is composed of red-sandstone rock. Still farther down stream the bottom is soft, the river entering upon alluvial lands which border its own course and that of the Connecticut river.

The Hockanum drains an area of 79 square miles. According to the report of General Theodore G. Ellis,(*a*) its greatest discharge at the mouth is 6,167 cubic feet per second, its mean discharge 132 cubic feet per second, and its least discharge 60 cubic feet per second.

a See page 55, Appendix B 14, *Report of the Chief of Engineers, U. S. army*, 1878.

With the exception of a moderate fall, variously estimated at from 8 to 12 feet,(*a*) situated in the town of Manchester, between Adams' paper-mill privilege and that of the Hartford Manila Company, no unimproved fall on the stream sufficient to constitute a separate privilege could be learned of.

At Rockville, manufacturing began to assume importance about forty years ago, and now there is a line of fine mills in close succession down through the valley. The place has a population of about 6,000. The fall is most rapid in the upper part of the village, and the Rock company is the first concern below the reservoir requiring a canal of much length. The dams are generally short and inexpensive. An equal number of breast-wheels and turbines are in use, and are considered to be of a good class. Steam is also employed for supplementary power at several of the mills. The principal manufacturing is of cassimeres, besides which cotton-warps, sewing-silk, stockinet, ginghams, satinet, and envelopes are also made.

Water-privileges on the Hockanum river at Rockville (in order below reservoir).

Company.	Manufacture.	Fall.	Horse-power of water utilized.
		Feet.	
Adams Manufacturing Company	Cotton-warps	16	1,300-1,400
C. White	Cotton	44	
Belding Brothers	Sewing-silk		
Samuel Fitch & Sons	Stockinet		
American Mills	Cassimeres	40	
Rock Manufacturing Company	do	27	
Do	do	22	
White Manufacturing Company	Ginghams	20	
New England Company	Cassimeres	20	
White, Corbin, & Co	Envelopes	19	
Springville Company	Satinets	18	
Hockanum Company	Cassimeres	18	
Do	do	10	
Total		254	

Passing below Rockville, the first privilege is that of the Ellington Manufacturing Company, at Windermere, running ten sets of cards on cassimeres. This mill has 24 or 25 feet head, and wheels of about 125 horse-power, of which only 90 is in use. Water is brought to the mill in a race a mile long. This holds a sufficient quantity to supply the wheels for an hour and a half, or until the water gets down in the morning from the Rockville mills. This long canal gives considerable trouble, however, in winter on account of ice; if it is drawn down much, the surface-ice sinks and freezes to the bottom, thus clogging the channel, and in this way the mill is forced to stop several times during the winter, though not more than a couple of hours at a time.

Below this mill all the other privileges on the stream, with one exception, are occupied by paper-mills. The most recently developed power is that of the Hartford Manila Company, at Woodland station, in the town of East Hartford. The dam was built in 1881, and is a framed structure resting on rock; it has a roll-way 100 feet long and 13 feet high, with masonry abutments. The water-wheels run under 14 feet head, and have a capacity of 220 horse-power. The water from Shenipsit lake does not reach this mill till late in the forenoon, and in general through the day the supply comes down stream very irregularly; but the Manila company, having a large pondage, stated to be at least 100 acres, is enabled to run steadily through the twenty-four hours. Full capacity cannot be realized from the wheels throughout the year, but the power is estimated not to fall below 60 horse-power, and the mill has conveniences for using steam in low water.

Water-privileges on the Hockanum river below Rockville.

Locality.	Firm.	Manufacture.	Fall.	Horse-power of water utilized.	Remarks.
			Feet.		
Windermere	Ellington Manufacturing Company.	Cassimeres	24-25	125	
Talcottville	Granite Mill	Paper	10	40	Has also a reservoir of a few acres above on the stream, with dam 8 or 10 feet high.
Oakland	Oakland Paper Company	do	23	125	Uses steam in low water.
Manchester	Union Manufacturing Company	Ginghams	20	250	Uses steam in low water. Pond estimated at 30 acres.
Do	Keeney & Wood	Book-papers	12-14	100-110	
Do	Peter Adams	Paper	16	180	Stone dam, built in 1877; 175 feet long, 14 feet high; cost $7,000. Pond estimated at 30 acres.
Woodland	Hartford Manila Company	do	14	220	Framed dam; 100-acre pond.

a It is said that a large storage could be obtained at this privilege, though with the necessity of a long dam.

Water-privileges on the Hockanum river below Rockville—Continued.

Locality.	Firm.	Manufacture.	Fall.	Horse-power of water utilized.	Remarks.
			Feet.		
Burnside	F. R. Walker & Son	Paper	10–11	[illegible]	
Do	East Hartford Manufacturing Company.	Fine paper	11	190	Wooden dam, built in 1858; 102 feet long; cost, $750.
Do	The Hanmer & Forbes Company	Paper	18	262	Can obtain full capacity from wheels about eight months in an average year; even in a very dry season the power is estimated not to run below 50 horse-power. Steam used constantly for supplementary power. The pond is small, and it has just been connected with a side reservoir of 26 acres, to gain more storage. In very high stages the Connecticut backs up to this privilege and causes a stoppage of the mill for a day or two by back-water.

At Talcottville the Hockanum is joined by the Tancanhoosen, a small stream which is supplied by a reservoir of a few acres at the head, owned by the various mills below. This reservoir avails only a short time, and can be drawn down in two weeks by Talcott Brothers' mill. The lowest privilege on the stream is occupied by a small grist-mill with about 10 feet fall. Next is Talcott Brothers' mill, running six sets of cards on cassimeres, and using 21 feet fall and 60 horse-power. This amount can be realized about eight months in an average year, but in low water this mill, as well as the other principal ones on the stream, has to rely upon steam. The next power is owned by E. E. Hilliard, of Manchester, and used by John A. Smith, agent, for a shoddy-mill. Still above, the Ravine Mills Company has two mills for the manufacture of cotton-warps; and yet farther up stream there are two small saw- and grist-mills.

At Manchester the Hockanum receives another little stream, supplied by a reservoir, and furnishing power to several small mills; but no particulars concerning them were gained.

THE FARMINGTON (*a*) RIVER.

As regards extent of area drained, the Farmington river stands fourth in order among the tributaries of the Connecticut river, comprising within its basin 584 square miles. The West branch heads in the town of Becket, in Berkshire county, Massachusetts, and running southerly and southeasterly enters Litchfield county, Connecticut; it passes across the northeastern part of this county, and in the town of New Hartford is joined by the East branch. The main stream thence pursues rather an unusual course: flowing southeasterly about 12 miles by straight course, it then turns in the town of Farmington, through considerably more than a right angle, and runs for 14 miles almost due north; at Tariffville it again turns as sharply as before, and, striking through a picturesque gorge in the hills, takes a curving southeasterly course to the Connecticut, into which it empties about 5 miles above Hartford. Its length from the extreme source of the West branch is, by river, 75 miles.

No data showing accurately the elevation at the source of this river could be obtained. At Becket station, a neighboring point on the Westfield river, the Boston and Albany railroad is about 1,200 feet above tide, and the headwaters of the Farmington probably have at least that altitude. It is stated by Mr. Robert R. Smith, agent of the Greenwoods Company, at New Hartford, that actual survey has shown a fall of 260 feet from Otis reservoir to the mouth of its outlet, and 625 feet thence to the top of the company's dam. The latter distance being about 21 miles, the fall given for it corresponds very nearly to 30 feet per mile. The fall in the river below New Hartford, as shown by railroad elevations, is given in the accompanying table:

Table showing the fall in the Farmington river.

Locality.	Elevation above mean tide.	Fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Feet.	*Feet.*	*Miles.*	*Feet.*	
Mouth of Otis Reservoir outlet	1,034				Approximate.
		625	21	29.76	
Top of Greenwood Co.'s dam	409				Elevation obtained by adding 30 feet to that at Pine Meadow.
		30			
Pine Meadow (*a*)	379				At crossing above dam.
		84			
Collinsville (*a*)	295		13	17.54	At crossing above village.
		22			
Do (*a*)	273				At crossing below village.
		92			
Farmington (*a*)	181				At crossing north of station.
		178	29	6.14	
Mouth of river	3				Estimated elevation at extreme low water above mean level of Long Island sound.

a Elevation of water-surface referred to mean sea-level. From profile of New Haven and Northampton railroad.

a Indian name, "Tunxis."

The flow of the stream was measured at Unionville, July 31, 1877, by General T. G. Ellis, in connection with a plan for supplying the city of Hartford with water from the river, and was found to average about 190 cubic feet per second for the twenty-four hours.(a) In his report upon the Connecticut river between Hartford and Holyoke,(b) General Ellis gave the least discharge of the Farmington at its mouth as 450 cubic feet per second; mean discharge, 944 cubic feet per second; greatest discharge, 24,375 cubic feet per second. In their work upon the *Construction of Mill Dams*, Messrs. James Leffel & Co. state the average discharge for the twenty-four hours, at New Hartford, in time of ordinary drought, at 168 cubic feet per second. These various results may be thus presented:

Data concerning the flow of the Farmington river.

Locality.	Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Flow per second per square mile.	Remarks.
		Sq. miles.	*Cubic feet.*	*Cubic feet.*	
New Hartford	Ordinary drought	225	168	0.75	Flow as given by Jas. Leffel & Co.
Unionville	Drought	357	190	0.53	Measurement of July 31, 1877.
Mouth of river	Least discharge	584	450	0.77	Discharge as given by General T. G. Ellis.
Do	Mean discharge		944	1.62	
Do	Greatest discharge		24,375	41.74	

The surface of the main portion of the Farmington River basin is hilly, with the ridges generally wooded and the valleys more or less cleared for farming purposes. As shown in the foregoing table, the flow of the stream is well maintained in the dry season, comparing favorably with the best New England streams. This character is due in part to natural conditions, the wooded character of the surface and the abundant springs, and largely also to one or two important storage reservoirs. The principal of these is known as the Otis reservoir, lying in the Massachusetts town of that name, and flows a surface estimated at from 1,000 to 1,300 acres. It is a valuable reservoir, and is indeed regarded as the chief source of supply for the river in the dry season. It is owned by the Farmington River Water Power Company, a stock association, in which the Collins and Greenwoods companies own more than three-quarters, and which they therefore practically control, although some other mill-owners farther down stream are also stockholders. For economical use by these large owners this reservoir has the disadvantage of being more than 20 miles away from the nearer of them, though it is for the same reason of advantage to all the intervening portion of the river. Otis reservoir has a drainage area of 11 square miles; it usually fills in spring, and is drawn upon to the extent of about 24 feet from full-water line, the draught commonly being made from May to November.

Long lake, at Winsted, is roughly estimated to cover 800 or 1,000 acres, although on Clark & Tackabury's map of the state of Connecticut it measures only 570 acres. It is drawn upon continuously through the year, and furnishes power to numerous establishments at Winsted; its waters reach the Farmington about 7 miles above New Hartford. At the latter point, the Greenwoods Company's dam forms a pond of large size, the area of which could not be ascertained. Shepherd's pond, lying 3 miles west of New Hartford village, is owned by the Greenwoods Company and used for storage purposes; it measures 170 acres on the state map, though its flowage is probably much greater than that, and can be drawn down 8 feet. There are a number of other ponds in the upper Farmington basin, of moderate size, which may serve to some extent for storage, but no special data regarding them were to be found, and even their areas as stated below cannot be relied upon as accurate:

Principal ponds and reservoirs in the Farmington River basin.

Name of pond.	Locality—town and state.	Area.	Remarks.
Tributary above New Hartford.		*Acres.*	
Otis reservoir	Otis,(a) Massachusetts	1,000–1,300	Owned by Farmington River Water Power Company. Is drawn upon 23–24 feet.
Lower Spectacle pond	Sandisfield, Massachusetts	113	Area as given by H. F. Walling; see Appendix B, *Report of the Massachusetts State Board of Health*, 1878.
Shaw pond	Becket, Massachusetts	100	Area as given by H. F. Walling.
Cotton pond	Tolland, Massachusetts	580	Do.
Long lake	Winchester, Connecticut	570	Area measures 570 acres on state map, but is estimated by manufacturers at from 800 to 1,000 acres. Drawn upon continuously.
Burrville pond	Torrington, Connecticut	90	Area by state map. Power used at outlet.
Shepherd's pond	New Hartford, Connecticut	170	Area by state map. Pond is owned by Greenwoods Company and used for storage. Can be drawn down 8 feet.

a Walling gives among the ponds in Otis: Great pond, 335 acres, and Rand pond, 235 acres. It is uncertain to what extent, if any, these are included in the reservoir here mentioned.

a Based on two measurements, one at 7 a. m. and one at 11 a. m. See *Report on Supply of Water from Farmington River.*

b *Report of the Chief of Engineers, U. S. army*, 1878, Appendix B 14.

Principal ponds and reservoirs in the Farmington River basin—Continued.

Name of pond.	Locality—town and state.	Area.	Remarks.
Tributary above New Hartford—Continued.		*Acres.*	
Doolittle pond	Norfolk, Connecticut	190	Area by state map. Pond is there represented as without any outlet. Other authority gives the area at 175 acres, and says a small dam raises the outlet about 4 feet.
Greenwoods pond	New Hartford, Connecticut		Estimated to contain several hundred acres.
East branch of Farmington river.			
Noyes pond	Tolland, Massachusetts	276	Area as given by H. F. Walling.
Pequabuck river.			
South Mountain reservoir			Not important.

There seems to be some difference of opinion among prominent manufacturers as to whether or not the storage capacity of the stream can be further greatly increased. It is definitely stated that, if sufficient money can be obtained, a new reservoir will be built above the present one in Otis, and on the same stream, to flow 738 acres 6 feet deep. Such a reservoir, if it could be relied upon to fill regularly, would certainly be of assistance to the stream; but it is claimed that, generally speaking, the opportunities for new reservoirs of much size are very limited, on account of insufficiently-large water-sheds.

The banks of the river are usually firm and of good height, while the bed consists of ledge rock or gravel. An exception to these conditions is the portion of the stream between Farmington and Tariffville, where its course lies through alluvial meadows. The width between banks ranges from perhaps 100 feet at Unionville to 250 or 300 feet near the mouth. The volume usually runs lowest in September, when the reservoirs have been drawn down, and highest during the spring freshets which visit the river in March or April. The ordinary spring-freshet depth on the dams at Collinsville and Poquonock, with roll-ways 325 and 243 feet long, respectively, is stated to be 3 or 4 feet. Below Farmington the slight slope of the stream causes it to spread out over the meadows during freshets, and produces an ordinary rise of 9 feet, and an extreme rise of 14 feet, below the site of the dam at that village. In the upper course of the stream, above New Hartford, the fall is rapid, the drainage slopes are steep and rocky, and freshets seem to be rather more sudden and violent than toward the mouth.

In the great storm of October 3 and 4, 1869, the water poured over the Collinsville dam 10 feet deep. This storm was a most remarkable one, and caused widespread damage in New England. It appeared to be central 2 or 3 miles east of New Hartford, where a downfall of 12.35 inches was recorded; the amount was above 8 inches over the entire Farmington River basin, ranging thence up to the maximum above mentioned. Valuable data regarding the distribution of rainfall in that storm have been prepared by Mr. James B. Francis, and presented in a paper read before the American Society of Civil Engineers.(*a*) Judging from the Smithsonian records, the average rainfall over the area drained by the Farmington river is about 11 inches in spring, 12½ in summer, 12½ in autumn, 10½ in winter, and 46½ for the year, increasing from the lower course toward the upper waters.

Privileges on the upper portion of the river experience some trouble from running ice, which gorges occasionally, but more from anchor-ice, which clogs the wheels and racks. At New Hartford the fine pond of the Greenwoods Company holds back ice until it has well rotted. Toward the mouth the usual run of ice is reported to be heavy; the depth of water on the dams is insufficient to carry it clear of them, and at Poquonock, at least, the works require more or less repairing in consequence every year.

Ascending the river, the principal manufacturing points are Poquonock, Rainbow, Tariffville, Unionville, Collinsville, and New Hartford. The manufactures are rather more diversified than ordinarily upon such a stream, comprising paper, hardware, cotton duck, worsted, and silks. Except above New Hartford and below Tariffville, the stream is conveniently accessible by railroad. From Collinsville to New Hartford two lines follow its banks, the Hartford and Connecticut Western, and the New Hartford branch of the New Haven and Northampton road. From Rainbow, and it is said also from Poquonock, merchandise is shipped to and from Hartford by team, a distance in the neighborhood of 10 miles.

Although there is much power already in use on the Farmington river, there are several valuable privileges still remaining undeveloped, as will be seen in the following more detailed account of the stream:

Water-powers.—The first dam met in ascending the river is about 5 miles above the mouth, at Poquonock. Rapids extend a considerable distance below, with moderate fall, but this is not sufficient to constitute a privilege of any value. In high water the Connecticut river sets back over these rapids, overflows the banks in places, and in extreme cases even submerges the Tunxis dam, just mentioned. Below the rapids there is smooth water to the mouth, and a small boat, the "C. H. Dexter", even ascends the stream a little way and lands freight for the farmers.

a Transactions, Vol. VII, No. 167.

The lower privilege at Poquonock is owned by the Tunxis Worsted Company, manufacturers of worsted yarns. The dam is a log structure 4 or 5 feet high, built in 1870 at a cost of \$2,000. It is 264 feet long, and gives a head at the mill of 7½ feet; 96 horse-power is used there, with surplus water always, night and day. The only especial hinderance is from backwater, which forces an occasional stoppage of work.

The next dam is in the same village, only a little way above the one just mentioned, and is owned equally by the Tunxis Worsted Company, which has a mill on the north bank, and the Hartford Paper Company, which uses power on the opposite side of the stream. The dam is framed, partly filled in with rock, and has stone abutments; it was built in 1844, is 243 feet long by an average of between 9 and 10 feet in height, and its cost is placed at \$25,000. There is used altogether, on both sides of the river, about 400 horse-power, under a head of 9 or 10 feet. For eight months in the year there is usually enough water for both establishments to run at full capacity, but for the remainder of the time they are troubled more or less by low water, and the Tunxis company is about to introduce steam for auxiliary power. It has more difficulty than the mill across the river, as a favorable current sets strongly toward the latter and carries to it more water, in a low stage at least, than the north side receives. The river-banks are of good height at Poquonock; the bed is entirely composed of red-sandstone ledges much worn and broken.

Succeeding the privilege just described is the one at Rainbow, a mile and a half by river above, occupied by three manufacturing concerns—the Hartford Paper Company, the Springfield Paper Company, and W. C. Hodge. The river-bed is here of the same character as at Poquonock, and ledge rock also crops out in the right bank. The dam is a crib-work of squared timbers, the back having a long slope, while the face slants more steeply a short distance from the crest, and then drops off vertically. It is supplemented by an embankment in which is a bulk-head of sandstone masonry. The length of the dam is 308 feet and its height 10 or 10½ feet; it was built in 1857, and its cost is stated at \$51,000. The canal has a total length from head-gates of perhaps 1,500 feet or more; it at first enlarges into a small pond, with a waste-way at the lower end, and then passes on to the mills. As usual with paper-mills, these run twenty-four hours in the day, and they all rely entirely upon water for power. The fall obtained ranges from 10 to 13 feet, according to position on the race, and the wheels in use have a total rated capacity of about 350 horse-power. In the dry season the supply of water is apt to be low on Mondays and Tuesdays, from its being held back over Sunday in the ponds on the upper river, but for nine months in the average of years there is a large waste over the dam. The canal gives trouble in severe winter weather by becoming clogged with ice.

Between Rainbow backwater and the foot of the Spoonville dam, the next one above, there is claimed, on good authority, to be a fall of about 30 feet. Of this, 24 feet 4 inches was actually surveyed, and the balance arrived at by a careful estimate. It is considered that the lower 4 feet could best be utilized by raising the Rainbow dam and incorporating it in that privilege. The succeeding 20 feet constitutes an unimproved privilege owned by Mr. R. D. Case, of Rainbow. Ascending above slack-water caused by the Rainbow dam, rapids are encountered which extend steadily for some distance up stream. The right, or south, bank is gravelly, steep, and high, rising abruptly from the water. The north bank is also steep at first, but soon the elevated ground recedes, and there is a gentle, steady rise from the river, presenting an extremely favorable site for building. Passing a little farther up stream, the south bank remains steep and high, while the north bank grows sandy. The river, which below shows gravel shoals, now exhibits several ledges of red sandstone extending regularly across its course and forming slight falls. Ledges also appear here in the south bank. The rapids extend some little way above, and are then succeeded by smooth water. A dam could be built under favorable conditions either on the rock ledges near the head of the rapids, or farther down stream; if the former site be chosen, a natural depression offers a convenient course for a canal. In any case, the north side is the one which would be chosen for building upon; two or three clear and permanent little streams run down the hill on that side, and are an advantage worth mentioning if the power were to be used for paper-manufacturing. It is considered by those interested that the privilege would best be developed by building a dam 9 or 10 feet high on the ledges mentioned, and extending a canal for say 1,000 feet down the north bank, thus increasing the fall to about 20 feet. Mr. Case wishes to dispose of the privilege; it is a good one and ought to be improved. What storage could be obtained above the dam is uncertain. During the dry season the same disadvantage would probably be experienced as at the mills below, namely, a scarcity of water on Mondays as compared with the rest of the week. Making an exception of this temporary and artificial reduction of power, the amount of which has not been ascertained, the capacity of the privilege may be estimated as follows:

Estimated power of Case's privilege at Rainbow.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	20 *feet fall.*
Low water, dry year	566	290	32.94	660
Low water, average year		340	38.62	770
Available 10 months, average year		440	49.98	1,000

The privilege here described is not especially convenient to the railroads at present, being 2 or 3 miles from the Hartford and Connecticut Western railroad at Spoonville, and some 4 miles from the nearest station on the New York, New Haven, and Hartford railroad.

The next power is at Spoonville, a small village, and is used by James Watson in the manufacture of horse-blankets. The mill is a small wooden one, and stands at one end of the dam, which is a framed structure and very leaky. The fall is 8 feet, and only about 16 horse-power is estimated to be used, although a large amount of water passes through the wheels, which are old and wasteful.

Estimated power at Spoonville.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	
Low water, dry year	555	290	32.94	260	16
Low water, average year		340	38.62	310	
Available 10 months, average year		430	48.85	390	

After leaving the alluvial meadows which border in common the Connecticut and the Farmington, near its mouth, the country along the latter stream rises somewhat and becomes level and sandy. The soil is largely cultivated, the better class for tobacco and corn, while on the sandy plains corn is almost the only production. There is a moderate amount of timber, mainly pine, chestnut, oak, and birch. Passing to the westward of this tract the soil becomes a red loam of good quality, well cultivated for tobacco. Shortly above Spoonville we encounter a trap ridge which runs north and south through the state. Through this ridge the river has found its way in a deep and narrow gorge, the precipitous sides of which display trap, ironstone, and some red sandstone, none of it of much value for building-purposes. The stream itself comes foaming down over a rocky bed.

Not far above the blanket-mill at Spoonville, H. A. Case has for many years had a 3-run grist-mill, where a fall of 6½ feet was in use. This privilege has now been purchased and incorporated in a much larger one by Mr. Horace Smith, of Springfield, Massachusetts. Mr. Smith owns about 50 acres of land bordering the stream in this vicinity, and also all the water rights for flowage from a point 4 feet below the level of the dead water in the tail-race of the Hartford Silk Company's mill down to the level of the water in the pond of the blanket-mill. The fall thus practically available is 30 feet, which is soon to be developed and used, it is said, in paper-manufacturing. A masonry dam 30 feet high and 225 feet long is to be built, and will give a pondage of 30 acres. Water will be taken directly from the pond in trunks, without the use of a canal. The privilege is 10½ miles by railroad from Hartford, and a spur from the Hartford and Connecticut Western railroad will run directly to the mill-sites.

The next power is a short distance above the gorge, and succeeds the one just described. It is occupied by the Hartford Silk Company, which manufactures all kinds of dress goods, upholstery goods, handkerchiefs, plushes, and velvets. The company began running in the spring of 1882, and at the time it was visited, in the fall of that year, was employing about 200 hands. The privilege has previously been occupied in turn by the Hartford Carpet Company, the Connecticut Screw Company, and the Hartford Cutlery Company. The dam is of crib-work, filled in with stone, and is 13 feet high and 160 feet long. About 300 horse-power of wheels are in place, under a head of 13 feet, but probably not over 100 horse-power was in actual use at the time mentioned. The pond sets back a long distance up the river, and thus gives a large storage, though mainly confined within the natural banks of the stream.

From Tariffville nearly to Unionville, through a distance of perhaps 16 or 17 miles, the course of the river is bordered by meadows, very fertile, well cultivated, and liable to overflow during spring freshets. The stream itself is described as having a fair current, though without shoals of any importance; its direction is winding, its bed is soft, and its banks are caving, these being usually of normal height on one side with low flats opposite. As Unionville is approached the meadows contract, the hills close in, shoals are encountered at intervals, the bed becomes gravelly, and some rock ledges appear.

The only dam in this stretch of river is at the village of Farmington, the privilege being owned by Messrs. J. E. and E. B. Cowles, of that place. The power is at present rented for a small 2-run grist-mill, using 4 or 5 feet fall and a single wheel of about 40 horse-power. The dam is a log structure over one hundred years old, filled in with loose stone and planked over; it has settled somewhat, and would admit of being raised a little above its present height. The principal trouble at this point is from backwater during freshets; more or less hinderance is thus experienced during four or five weeks in the year, and an occasional stoppage of work for a few days is rendered necessary. During the six years preceding 1882 the longest continuous period in which a stoppage was forced by freshet backwater was six days. Ice sometimes gorges in the river below, at a place known as the "Aqueduct", and backwater results at Farmington from that cause also. This difficulty has arisen twice in perhaps ten years, and on one of those occasions the mill was stopped for two weeks. The owners of this privilege are anxious to sell it. Aside from the period of high water, the effect of which in reducing the power may be judged to some extent from what has already been said, the available power may be estimated as follows:

Estimate of power at the Messrs. Cowles' privilege, Farmington, Connecticut.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*5 feet fall.*	
Low water, dry year	431	250	28.4	140	40
Low water, average year		280	31.8	160	
Available 10 months, average year		330	37.5	190	

The meadow-lands in this vicinity are valuable for corn and grass, and some of them are held at from $150 to $175 per acre. Succeeding the alluvial meadows, on the higher ground is a strip of gravelly soil extending up and down the valley, and best suited to corn and tobacco; still higher up, on the hills, the soil is a red loam.

The next privilege to be noticed properly includes the one last described, and is not in use, although it might be considered partly developed. It is owned by Mr. Edward Norton, of Farmington, who would be glad to see the power improved, but does not himself wish to undertake the enterprise. In order to a clear understanding, it may be stated that in the neighborhood of 1840 the New Haven and Northampton canal was in operation for several years. It had but little traffic, never paid as an investment, and was finally bought up by the present railroad, known as the New Haven and Northampton Company, and then abandoned. This canal, coming down from Northampton, Massachusetts, on the west side of the river, crossed over to the east side on an aqueduct about 2 miles below the village of Farmington, and continued thence southerly toward New Haven. Before crossing, the main canal received an important feeder, which, starting from the Farmington river, about a mile below Unionville, struck across the bend which the river here forms, until it joined the principal canal near the aqueduct. This feeder had a length of about 3 miles, and at its entrance was a dam, said to have been 18 feet high, across the river. The dam was carried out in the period from 1840 to 1850, and at about the same time the main canal was abandoned. There was no further use for the feeder, and the land along its course reverted to the former owners. At present, Mr. Norton owns the land at both extremities of the feeder, and much of the way along its line.

Nothing now remains of the old feeder-dam except one or two logs next the east shore, and all that shows of the entrance gate to the feeder itself is a little of the stone-work and two wooden posts. Midway between these posts the bed of the canal is about 4½ feet above low-water surface in the river immediately below the old dam. The canal seems to have been designed for a water depth of about 4 feet at the center, and a surface width of from 20 to 25 feet. It is now overgrown much of the way with saplings and brush. Some little way back from the river, near the aqueduct, the main canal received the feeder; it then approached the river on a high embankment, terminating in an abutment of red-sandstone masonry. This abutment is now in fair condition, though the mortar is worn from the joints. The abutment on the east side appears more dilapidated. The piers, five in number, which supported the aqueduct, still remain, and preserve tolerably well their original shape.

In the fall of 1877 Mr. C. H. Bunce, city surveyor of Hartford, ran a line of levels from opposite the entrance of the feeder to the aqueduct, to determine the intervening fall in the river, which he found to be 29½ feet.(a) The fall at the aqueduct, from the bed of the main canal to the river, is 34 or 35 feet, and it is this amount which Mr. Norton considers practically available for power.

Estimate of power at "Aqueduct" privilege, Farmington, Connecticut.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. Miles.*	*Cubic feet.*	*1 foot fall.*	*18 feet fall.*	*34 feet fall.*
Low water, dry year	9	14	14	9	46	360±	210	23.86	430	810
Low water, average year							240	27.26	490	930
Available 10 months, average year							280	31.81	570	1,080

The plan of development which is considered to be best suited to this power is to build a new dam 1,400 or 1,500 feet above the old one. It would have to be a very low affair, not over a couple of feet high, on account of danger of causing backwater on the Unionville privilege above. It would be inexpensive of construction and would rest upon a rock bed. On account of this danger of causing backwater at Unionville, I understand that it would not be practicable to raise the river sufficiently to utilize the feeder-canal in its present condition; or that, at least, any such attempt would be resisted by the Union Water Power Company. From the proposed site of the dam a canal would run down the east bank of the river to the entrance of the old canal. The starting-point of the latter was formerly located as has been described in order to avoid a rock-cutting which the new route would pass through,

a Report on Supply of Water from Farmington River.

but which it is thought would be more economical than a high dam at the site of the old feeder-dam. The whole length of new canal, 1,468 feet, would be a cut through red sandstone, which is stated to have been examined and found to be in part suitable for building-purposes. After striking the old feeder the course of that canal would be followed thence 3 miles to the vicinity of the aqueduct, although it would have to be deepened 4 or 5 feet and correspondingly broadened.

It is claimed that, if desirable, 18 feet of the fall on this privilege can be used within a mile of the head of the canal. The present line of the feeder is there from 100 to 120 rods from the river, but the ground is quite level and by a side-cut water can be conveyed to within 30 or 40 rods of the stream. The power can also be used, either entirely or in part, in the vicinity of the aqueduct. Above that point the west bank is comparatively level, and subject to overflow during high freshets. Below the aqueduct the immediate bank is 10 or 15 feet high and sandy. Farther back it rises and is above overflow. Here it is thought the power could be conveniently utilized, probably to the best advantage in two levels. There is ample room for mills and a village, and a mile or two of spur-track would connect with the New Haven and Northampton railroad.

An important power might evidently be obtained at the aqueduct, but a great disadvantage toward development is the length of canal necessary, the construction of which would probably involve a heavy expense. Backwater would be experienced in freshets, as at the Farmington mill, and the privilege occupied by the latter, which is intermediate between the head and foot of the old canal-feeder, would have to be purchased.

The power at Unionville, which is next to be noticed, was developed about 1830 by Messrs. Cowles, Morton, & Bidwell, and later came under the sole control of Mr. Cowles. Water was originally leased according to the flow through an opening 1 foot square, under a certain head. The question of measuring the water having arisen, the manufacturers claimed that measurement should be made through an aperture with rounded edges, to admit as large a discharge as possible, while the lessor insisted that the edges must be square, and extended law-suits arose in consequence. About the year 1878 the manufacturers here combined to form a stock company, which took a long lease of the entire property, with the right to purchase after due notice, which has since been given. They obtain the whole property, including two factory buildings, for $50,000. The title of the new proprietors is the Union Water Power Company; they own a total fall of 36 feet, which is used from two levels, with 18 feet fall from each. The company sells the land to manufacturers and gives a perpetual lease of power. The established rental for the latter is $175 per mill-power, a mill-power being assumed at 7½ cubic feet of water per second under 18 feet head.(a) In practice, the wheel ratings are employed to determine the amount of water used. In the fall of 1882 about 1,000 effective horse-power had been leased, and it was stated that within a few months the full amount would be in actual use. So far as regards its capacity to supply permanent power, this privilege is considered to be fully developed, and the company can not therefore insure constant power to new concerns. In priority of rights during low water the various lessees are claimed to rank according to date of lease. Four of the largest concerns employ steam for auxiliary power, during low water at least. The paper-mills run twenty-four hours in the day, and the other establishments ten or twelve hours.

The river-bed at Unionville is composed of gravel, bowlders, and frequent rock ledges, inclined at a large angle. The dam rests upon a gravel foundation, and is a log crib-work filled in with loose stone. The logs are from 10 to 12 inches in diameter, with transverse binders once in 5 or 6 feet. The dam rises 10 feet above the river-bed, is 4 feet wide on top, and has a back slope of 1 in 3. From the crest the face pitches down stream for 12 feet, with about the same slope as the back, and is succeeded by a horizontal apron 12½ feet wide; at the end of the apron there is a drop vertically of 5 feet to the river-bed. The apron is a continuation of the crib-work of the dam, and is covered with two layers of heavy planking, the lower 6 and the upper 4 inches in thickness. At the foot of the dam a row of round piles was driven into the river-bed. The abutments and bulkhead are of granite rubble masonry, rising about 12 feet above the crest of the dam. Below the dam the east bank is protected by a shore-wall, and the west bank by timber and stone crib-work. The bulkhead has seven rectangular gate-openings, through which water is admitted to the canal. The main canal follows down the east bank, running much of the way along a side-hill; it is about a mile and a half long, and, though varying in width, averages perhaps 25 feet, with a water depth of 5 or 6 feet. At its extremity surplus water passes down into the second or lower level and is discharged thence into the river. The lower level canal is about 1,000 feet long, with a width of 20 feet and a water depth of 4 or 5 feet. The concerns using power are as follows:

From the upper level—

1. The Ripley Manufacturing Company; has now a turning shop, and will soon engage in the manufacture of paper.
2. The Meach & Hart Manufacturing Company, cutlery; sublets some power to the Standard Rule Company.
3. The Platner & Porter Manufacturing Company, two paper-mills.

From the lower level—

1. The Delaney & Munson Manufacturing Company, paper.
2. The Union Nut Company, bolts and nuts.
3. The Cowles Paper Company.

These concerns employ in all about 450 hands, mostly men.

a Accordingly as the wheel efficiency ranges from 60 to 80 per cent. will the value of a mill-power range from about 9¼ to 12¼ effective horse-power.

It requires three hours for the water used at Collinsville to reach Unionville. The amount stored above the dam at the latter point will run the mills only about six hours. For three or four days every year, while the Collins Company shuts down for inventory, which time the Greenwoods Company generally improves for repairs and other work, the water is held back above, and the mills at Unionville are also obliged to shut down.

In winter anchor-ice clogs the head-gates at the entrance of the main canal, and the level being drawn down, the surface-ice in it sinks, freezes to the bottom, and hinders the passage of water. The trouble is a serious one, lasting sometimes for two or three weeks, until there is a sufficient change in the weather to loosen or melt the ice, but might be avoided by temporarily shutting down the mills when the head-gates become clogged.

Estimate of power at Unionville.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	36 *feet fall.*	
Low water, dry year	9	14	14	9	46	357	210	23.86	430	860	*a* 750–1,000
Low water, average year							240	27.26	490	980	
Available 10 months, average year							280	31.81	570	1,140	

a 750 horse-power of wheels in 1880 by census enumerators' returns; about 1,000 horse-power said to be leased in 1882.

Intermediate between the Union Water Power Company's dam and the foot of its privilege is a low dam, similar in construction to the one already described. It diverts water into a race on the west side of the river, supplying George Richards & Co.'s 3-run grist- and saw-mill. This firm has 9½ feet head and uses about 50 horse-power. Reliance is placed entirely upon surplus water from the upper dam, and for about nine months in an average year the mill can be run at full capacity.

Above Unionville backwater the river is a succession of shoals and pools. The bed is covered with gravel, and in some places with bowlders. The New Hartford branch of the New Haven and Northampton railroad follows the west bank, usually at an elevation of 15 or 20 feet above the water-surface. It was stated that the railroad company had expressed its willingness to raise the track if it should prove necessary in the development of the water-power. The west bank is nearly all the way steep and high, and does not present good opportunity for building. The east bank shows rock ledges in places, and is also much of the way quite abrupt, rising to hills; but in two localities there is ample building-room. One of these is shortly above the Unionville pond. The other is near a stone-quarry, not over a mile below Collinsville. At the latter point the river makes a bold curve, and incloses a large piece of gently-sloping ground, finely suited to building. This privilege is owned by the Collins Company, which roughly estimates the available fall at 10 or 12 feet. No data showing the exact fall between the present Collinsville and Unionville developed powers have been obtained, but, judging from the elevations previously given for the New Haven and Northampton railroad, it is probably not less than 35 feet.

Estimate of undeveloped power on the Farmington river, between Unionville and Collinsville (assuming a fall of 35 *feet).*

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	Theoretical horse-power.	
	Square miles.	*Cubic feet.*	1 *foot fall.*	35 *feet fall.*
Low water, dry year	*b* 334–*c* 357	200	22.72	800
Low water, average year		230	26.13	910
Available 10 months, average year		270	30.67	1,070

a Above Unionville the mills run only ten or twelve hours per day, and the stream is so controlled that its flow is concentrated within that time; consequently during low stages double the flow and power here given could be realized for the ordinary working hours.

b At Collinsville. *c* At Unionville.

The power at Collinsville is owned by the Collins Company, manufacturers of edge-tools, axes, plows, and other iron and steel goods. The works were established about 1826, and now give employment to 600 men. The various shops and other buildings extend 1,800 feet down the east bank, and an average of 400 feet back from the stream. The dam rests upon huge outcropping ledges of granitic rock, and is built of cut-granite blocks, rock-faced; the roll-way is 325 feet long, and from the bulkhead a canal leads 1,500 feet down the bank to the different shops. The pondage above the dam is sufficient to run the works for about four hours. It requires six hours for the large volume of water in use at New Hartford to reach this point, but an arrangement exists with the Greenwoods Company by which the water is sent down in time to meet the Collins Company's needs. The maximum power in use is 1,150 horse-power. The privilege has a fall of 20 feet, and is commonly rated by the owners at 1,000 horse-power for the working-hours of the day, but for two or three weeks in a dry season there is a scant supply of water, and it is estimated that the power probably sinks as low as 800 or 850 effective horse-power.

Between Collinsville and New Hartford the hills now and then close in upon the river, while at intermediate points the valley is comparatively open, with a gradual rise to high wooded ridges. The stream-bed is gravelly, with frequent shoals. The profile of the New Haven and Northampton railroad shows a descent of 84 feet from the water-surface above the Pine Meadow dam to that above the Collinsville dam. Of this, 17 feet is in use at Pine Meadow, leaving 67 feet unimproved. This fall is largely owned by various farmers whose land is adjacent to the stream, and, so far as could be learned, there are only two or three points at which the ownership is in such condition that a distinct water-privilege is claimed.

A short distance above Collinsville, Mr. Julius Case, residing near by, claims an available fall of 12 feet, to be obtained by a dam 6 feet high and a canal 50 rods long.

At a point nearly 4 miles above Collinsville, known as "Satan's Kingdom", Mr. D. B. Smith, of Pine Meadow, owns a privilege extending from the foot of the old "Puddletown sluice" to the foot of the gorge through which the river runs at the "kingdom". Mr. Smith formerly considered his privilege to embrace 18 feet fall, but claims that the action of the railroads in throwing excavated rock into the stream has resulted in shifting 8 feet of the fall to below the limit of his ownership, leaving the present fall on his privilege 10 feet. The gorge to which reference has been made is not unlike the one farther down stream at Tariffville; it is narrow, and hemmed in by high, almost vertical, walls of solid rock. A branch of the New Haven and Northampton railroad runs along the west side, about 20 feet above low water in the stream; and on the opposite side is the Hartford and Connecticut Western railroad, 5 or 10 feet higher. In this confined passage-way the freshet-rise is large, and within ten years is said to have reached the Northampton track. It would not therefore answer to build a dam in the narrows, but by giving sufficient length of roll-way at some point below, an undue rise there could be avoided. The gorge is about 800 feet long, the river falling perhaps 5 feet in that distance. Below the gorge the river widens and forms a deep, quiet pool. The hills recede and the west bank becomes low and sandy; 1,500 feet below the narrows there is a second pitch, of 4 or 5 feet in 200 feet. The river is there wide, incloses a low island, and has a gravelly bed; the west bank rises about 10 feet, and the New Haven and Northampton Railroad track is about 15 feet, above low water. Perhaps the best method of improving this portion of the river, and one that would use safely a part, at least, of the fall at Satan's Kingdom, would be to locate a dam at a point about half a mile down stream, at the foot of a long meadow.

At a place called Puddletown, a short distance below Pine Meadow, a low dam formerly ran across the river, and a canal down the west bank carried water to puddling-works, using 8 feet fall. The former owner and Mr. D. B. Smith carried on a lawsuit for six years over the question of backwater from this dam setting upon the privilege above. Mr. Smith was successful in the suit, and the dam was afterward removed. The privilege is now said to be owned by Mr. William Caul, of Pine Meadow, and is for sale.

The extent to which the 67 feet of unimproved fall between Pine Meadow and Collinsville can be utilized is to be determined only by careful examination; supposing that it were possible to use the whole amount, the corresponding power, as well as the power for lesser falls, may be estimated as follows:

Estimate of unimproved power between Pine Meadow and Collinsville.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. (*a*)				
	Spring.	Summer.	Autumn.	Winter.	Year.							
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	*10 feet fall.*	*12 feet fall.*	*67 feet fall.*
Low water, dry year	9	14½	14½	10	48	*b*225–*c*291	170	19.31	150	190	230	1,290
Low water, average year							200	22.72	180	230	270	1,520
Available 10 months, average year							230	26.13	210	260	310	1,750

a In low stages of river the power could be doubled for ten or twelve hours in the day. *b* At New Hartford, *c* At Satan's Kingdom.

The Pine Meadow privilege embraces a fall of 17 feet. A half-mile above the mills a low dam, old, and built of logs, extends across the river, presenting an angle up stream. Water is conveyed thence for use through a canal 30 feet wide and 6 feet deep. Mr. D. B. Smith owns one-half of the power, and uses it in the manufacture of cotton duck, furniture, and hardware; he has also a brass- and iron-foundery, a grist-mill, and a saw-mill. Seven-sixteenths of the power is owned by H. Chapin's Son, and used for a machine-shop, iron-foundery, and in the manufacture of carpenters' tools. The remaining one-sixteenth of the privilege is owned by Mr. Robert R. Smith, of New Hartford.

Probably the finest privilege, all things considered, on the Farmington river, is that of the Greenwoods Company, at New Hartford. The fall of 30 feet is equaled by that designed for the new Tariffville power, but is only surpassed, among the improved powers, at Unionville, where there is a total fall of 36 feet. The Greenwoods Company has the advantage of a very large storage above its dam, which enables it easily to control the low-water flow of the stream. The management of the large reservoir in Otis, 24 miles above, is directed from this point, there being communication by telephone, and every possible economy is practiced in the use of water. It is stated to require twenty-four or forty-eight hours for water to reach New Hartford from this reservoir, accordingly as the gates there are opened entirely or only half-way. The Greenwoods Company manufactures cotton-duck, running

25,000 spindles and employing 700 hands; it uses about 800 horse-power. Water is used in two falls, of 18 and 12 feet, respectively; first, near the east end of the dam, whence it is conveyed in a race some distance down to the lower mill.

The roll-way of the dam is variously stated at from 210 to 230 feet in length; it is 25 feet high, and is supplemented by an earthen embankment 35 feet high and nearly 400 feet long. It was built in 1848, and by its long endurance gives evidence of having been well designed and constructed. The details of construction are given at considerable length in James Leffel & Co.'s work on the *Construction of Mill Dams*, from which these notes are mainly taken.(*a*) The river-bed at the site of the dam is composed of cobble-stones, gravel, and quicksand. The banks are gravel and sand. The structure itself is a crib-work of timbers from 9 to 12 inches thick, and slopes both up stream and down from the crest, at angles of about 27° with the horizontal. The foundation timbers are laid crosswise of the stream, the next layer with the stream, and so on. Those timbers running with the stream are 6 feet apart from center to center, the ends coming flush with the face and back of the dam; those running transversely leave a clearance of 2 or 3 feet. The intersections are fastened with spikes of $\frac{3}{4}$-inch round iron 20 inches long. Throughout the structure all spaces are filled in with loose stone. At the foot of the back slope is a line of sheet-piling, designed to prevent leakage under the dam. At the end of, and partially supporting, the apron is a row of piles. The apron itself is composed of timbers 12 inches thick, placed close together; it is securely bound to the main portion of the dam by extending a timber, once in 6 feet, 25 or 30 feet under the latter, while the remainder extend under only 2 or 3 feet. The apron projects 14 feet from the foot of the dam. Timber and stone cribs placed in the river-bed below the apron and secured to the latter prevent scour from the overfalling water.

Summary of water-privileges on the Farmington river, from New Hartford to the mouth.

Locality.	Drainage area.	Fall.	Gross or theoretical horse-power.(*a*) Low water, dry year.	Low water, average year.	Available ten months, average year.	Remarks.
	Sq. miles.	*Feet.*				
New Hartford	225	30	.....	.....	.....	Power utilized by Greenwoods Company.
Pine Meadow	.....	17	.....	.....	.....	Power utilized for several kinds of manufacturing.
Puddletown (near Pine Meadow)	.....	[illegible]	150	180	210	These privileges are particular ones brought to notice, and do not cover the entire fall from Pine Meadow to Collinsville.
Satan's Kingdom	291	10	190	230	260	
Short distance above Collinsville	334	12	230	270	310	
Total from Pine Meadow to Collinsville	.....	67	1,290	1,520	1,750	This fall is entirely unimproved, and probably not all could be developed to good advantage.
Collinsville	334	20	.....	.....	.....	Utilized by the Collins Company.
Collinsville to Unionville	.....	*b*35	800	910	1,070	Unimproved.
Unionville	357	36	860	980	1,140	Owned by Union Water Power Company, and largely utilized.
Do	.....	9½	.....	.....	.....	Intermediate between dam and tail-race of above privilege. Used by grist-mill.
Farmington (aqueduct power)	360±	34	810	930	1,080	Unimproved.
Farmington (Cowles' power)	431	5	140	160	190	Intermediate on above privilege. Small power in use by grist-mill.
Tariffville	.....	13	.....	.....	.....	Occupied by the Hartford Silk Company.
Spoonville	555	30	990	1,160	1,470	To be improved by Horace Smith, esq., of Springfield, Massachusetts.
Do	.....	8	260	310	390	Small power used in Watson's mill in the manufacture of horse-blankets.
Rainbow (Case's power)	566	20	660	770	1,000	Unimproved. A fine privilege.
Do	.....	10–13	.....	.....	.....	Utilized by three paper-mills.
Poquonock	.....	9–10	.....	.....	.....	Power utilized by Tunxis Worsted Company and Hartford Paper Company.
Do	.....	7½	.....	.....	.....	Power utilized by Tunxis Worsted Company.

a Estimated on basis of average flow for the twenty-four hours. *b* Estimated.

Ascending the West branch of the Farmington river above New Hartford, we find the surrounding country hilly and wooded, with many steep and rocky slopes. The timber is largely the younger growth and confined to the ridges, having been cut lower down. Farming is carried on to a moderate extent, but the land does not appear very productive. The river is almost a constant succession of shoals, with a bed of gravel and bowlders, and firm banks. The discharge from Otis reservoir passes down this branch, and is, of course, a great assistance during the dry season; but that reservoir, controlled by the companies farther down stream, is drawn upon rather irregularly, so that while much of the time a large amount of water wastes past the mills, there are intervals when the supply is insufficient. This disadvantage is especially noticeable above Riverton, where the water from Winsted comes in. The method of using the upper river is by low dams and long races; in consequence very little water is stored, and so there is no safeguard against the irregularities of flow that have been mentioned.

a There may have been minor changes since that description was published, but it is without doubt substantially correct.

Generally speaking, however, this part of the stream is naturally favorable for improvement. The gravelly bed offers good foundation for dams. The hills close in at points so as to leave no good building-room, but there are frequent intervales where there is abundant space. At such localities one bank or the other is apt to be rather low, but toward the head or foot of an intervale the banks are usually of fair height. A dam high enough to set back the river over one of these intervales, or over any considerable part of one, would give a large pondage; the land covered would be the best in the valley, but could not be of great money value. One objection to the use of power on this section of the stream is the lack of railroad facilities, which extend only a little above New Hartford. A line is said to have been graded between Lee, Massachusetts, and Colebrook River, Connecticut, but the company failed and the work ceased.

North of New Hartford the first privilege is at Pleasant Valley, just above the Greenwoods pond. A couple of low dams, several hundred feet apart, rudely made of bowlders, serve to divert water into a race on either side of the river. On the east side are a number of unoccupied buildings; carriages were formerly manufactured there, but a suit regarding the water-power arose with the Greenwoods Company, and the property was finally purchased by it. On the west side perhaps 15 horse-power and 7½ feet fall are used by Albert Baker & Son in the manufacture of sashes, doors, and blinds.

The next power is also in Pleasant Valley, and is occupied by Messrs. D. & E. J. Youngs for a saw-mill. They have a log dam 200 feet or more in length and 5 or 6 feet high, from which water is brought in a race about a quarter of a mile to the mill, where 12 feet fall is obtained. The ordinary freshet-rise on the dam is about 4 feet; a much higher rise carries the water on to flats which extend back on the east side.

Between Pleasant Valley and Riverton there are two unimproved powers. The lower is owned by the Messrs. Youngs, of the former place, and has a fall estimated at 12 or 15 feet. The second, which might, if desired, be separated into two privileges, extends from the Youngs privilege to within three-quarters of a mile of Riverton, and embraces 24 feet fall. It is owned by Mr. H. Goodwin, of Riverton, who also owns in connection 120 acres of land, 25 of which, on the east side of the river, is claimed to be suitable for building-purposes.

At Riverton, above the mouth of Sandy brook, Stephens & Co. use 8 feet fall and 20 horse-power in the manufacture of rules; they can run at full capacity nearly all the year.

In the same village, farther up stream, Ward Brothers have a manila-paper mill, where they use 12 feet fall and 135 horse-power. They run twenty-four hours in the day, and are short of water perhaps one month during the year, in periods of a few days at a time when the Otis reservoir is not being drawn upon. The dam is a timber structure, 180 feet long and 4 or 5 feet high, and was the first built between New Hartford and Colebrook River. Water is brought to the mill through a race about a quarter of a mile long.

Between Riverton and Colebrook River, a distance of about 5 miles, there is considerable unimproved fall, said to amount to 100 feet or more. The stream is 70 or 80 feet wide, and of the same general character as below Riverton. At Colebrook River, H. S. Sawyer has a cotton-duck factory running 3,600 spindles and employing 115 hands. About 100 horse-power is probably in use, from wheels rated at 170 horse-power and working under 18 feet fall. The pondage is small and would not supply the mill more than four hours. In the low water of September, 1882, without receiving any supply from Otis reservoir, this mill could be run at about three-quarters capacity.

The stream was not visited above this point: there were reported to be several small establishments above, but no important use of power was mentioned.

TRIBUTARIES OF THE FARMINGTON RIVER.—*The East branch.*—This stream empties just below Pine Meadow, and has at present but little value for power. So far as ascertained it is not supplied by any reservoirs, although it is said that some storage room might be put to use in the upper waters. Its lower course lies through a somewhat narrow valley, the side slopes of which are wooded, often very abrupt, and occasionally display huge precipitous ledges of bare rock.

The only dam within 10 or 12 miles of the mouth is at Barkhamsted Hollow, where Wallace Case uses 13 feet fall for a small grist- and saw-mill. He has one water-wheel, rated at 47 horse-power, and thinks that with a tight dam it could be run, on the average, ten months in the year at full capacity.

The stream is very flat in this part of its course, and is said to continue thus well up toward its head. Mr. Case states that for 6 miles above his privilege the slope is so small that by raising his dam from 4 to 6 feet he considers that the stream would be set back over the whole distance and the surrounding meadows flooded. Between Case's mill and the mouth, at least, the river-bed is gravelly, the banks are low and are composed of sand or gravel; the water is very clear, and in a low stage there is to be seen only a series of quiet pools, between which the shoals are scarcely covered with water. The general slope being small, storm-waters are not promptly carried off, and a heavy shower 3 miles above Case's mill is sufficient to bring the stream out of its banks into the bordering meadows. Ordinarily, in its lower course, the stream begins to rise about 6 hours after the beginning of a rain, and to fall at an equal interval after its cessation. Below Case's dam a common freshet-rise is 5 feet, and an extreme rise 13 feet.

Power at Winsted.—It is interesting to note the number and variety of manufactures which have here developed a thriving borough of 1,800 inhabitants, and which are supported by little streams. These industries have started from small beginnings, and have grown steadily in size and number. The manufactures are nearly all in metal, and

employ a good many hands in the aggregate, with a large production of goods, without, however, requiring very large powers. The main village and two other villages, called, respectively, East and West Winsted, lie scattered along a rather narrow valley among high hills. Three streams are in use. Mad river comes down from the town of Norfolk, and is the main stream as regards length and size of drainage area. At Winsted, just above Persons' dam, it receives what is called the "Lake stream", and a short distance below the Strong Manufacturing Company's privilege it unites with Still river, which comes from Burrville and gives its own name to the succeeding portion of the stream. Most of the mills receive the benefit of the Lake stream, which is the principal and most reliable source of supply. The lake holds back ice and freshets, and the village would be almost free from the latter but for an occasional large rise in Mad river. The mills are mainly of moderate size, but there are several large and wealthy manufacturing concerns. Water furnishes the sole motive power in nearly all cases, though a few of the larger establishments also employ steam more or less of the time. The fall is practically all improved in Winsted along the course of the Lake stream, but there is some yet undeveloped on Mad river above the Empire Knife Company's works.

Long lake is about 2½ miles in length, and is estimated to cover from 800 to 1,000 acres, though on the state map published in 1859 it measures only 570 acres. It is a natural pond that has been raised, and though it can be drawn down 10½ feet from a full stage, there then remains a depth of 60 feet in places. One or two little streams drain into it, and its entire water-shed includes 6.5 square miles. In the average of years it fills to within about a foot of full-water line. In 1882 it lacked a little over 2 feet of filling, while in 1874, for a time, water is said to have wasted 9 inches deep over two waste-weirs of 100 feet each. The borough water-supply is from this lake, and absorbs a considerable amount of its water. The lake affords a very steady power to the mills on the stream below; it is drawn upon throughout the year to the amount of 1,600 cubic feet per minute, which it seldom fails to furnish. Twice in eleven years the supply has run somewhat short, at one time for a period of five months and at another for three months. September 9, 1882, after a very dry season, the water surface was 6¾ feet below full-water line, and was being drawn down about three-quarters of an inch a day. The dam would admit of being raised higher, and a plan is under consideration to tap Mad river at a point above the borough, and by means of a canal 2 or 3 miles long convey its surplus waters to the lake.

The uppermost establishment in Winsted, on Mad river, is the Empire Knife Company. A short distance up stream it has a reservoir of several acres, which can be drawn down 25 feet, and between this reservoir and its factory it owns several unimproved powers.

The various falls in use at Winsted, and some facts regarding the manufacturing, may be learned from the following table:

Water-privileges at Winsted and vicinity (in order descending).

Firm.	Manufacture.	Fall. (a)	Rated horse-power of wheels. (a)	Remarks.
Lake stream.		*Feet.*		
	Turning-shop	17		
	Saw-mill	19		
Henry Spring Company		16	45	
Beardsley Scythe Company		28	110	
Winsted Manufacturing Company	Scythes	20		
Hulbert Iron Works		14–16(?)		
T. C. Richards Hardware Company		12	30	Transfers small power by cable to Winsted Silver Plate Company.
Winsted Hoe Company		21	55	
Mad river.				
Empire Knife Company		18–20		35-inch National wheel. In average year can run full capacity eleven months.
George Dudley & Son	Tannery			
John T. Rockwell	do	13	30	
Wing Persons	Feed-mill	8½	23	Lake stream empties into pond above the dam.
Thayer Scythe Company		10		Works closed permanently.
Winsted Foundery & Machine Company		6½	15(?)	
New England Pin Company		9	54	Can run at full capacity by water-power about nine months. Uses steam in addition. Rents occasional surplus power to a grist-mill.
Winsted Hoe Company		10	40	
Strong Manufacturing Company	Undertakers' hardware	7⅝	38	
Still river below Mad river.				
William L. Gilbert Clock Company		18	72	Large concern, employing 200 hands. Can run at full capacity by water-power nine or ten months. Uses steam in low water. Leaky wooden dam on rock ledge.
Winsted Manufacturing Company	Scythes, corn-knives, etc.	14–16		
Franklin Moore & Co.	Norway bolts and nuts	13–14		One privilege.
R. Cook & Sons	Fine carriage-axles			

a Approximate.

Shortly below Winsted, F. Woodruff & Son use power for a grist-mill. About a quarter of a mile above Robertsville the stream passes through a rocky gorge and over an abrupt fall. It is said that with a high dam 35 feet fall is available there.

At Robertsville, not far above its confluence with Sandy brook, Still river runs through another narrow passage-way in the rocks, falling over 40 feet in a little distance. Fourteen feet of this fall and 25 or 30 horse-power are here employed by the Union Chair Company.

Below the junction of Sandy brook and Still river, sometimes the one name and sometimes the other is given to the main stream. Thence to the Farmington only one power is in use, and that is at Riverton, near the mouth, where the Eagle Company uses 14 feet fall and from 60 to 75 horse-power in the manufacture of scythes. A grist-mill is supplied from the same privilege.

The Pequabuck river is a small stream draining 60 square miles, embracing portions of the towns of Burlington, Harwinton, Plymouth, Bristol, and Farmington, in the latter of which it joins the Farmington river from the south. It is very flat near the mouth, but falls more rapidly above, and has a gravelly bed. Formerly it was supplied in part by Mine pond, which it is stated has now been drawn down and will no longer be used. Above Forestville the stream branches, the south branch being the more important and receiving considerable assistance from South Mountain reservoir, said to be half a mile long, but the area of which could not be ascertained. The reservoir fills regularly, and can be drawn down some 12 or 14 feet from full-water line. Although the Pequabuck furnishes a large number of small privileges,(*a*) it is of no especial importance for power, and all the principal manufacturing concerns on its course have to rely largely upon steam. The most prominent users of power are the E. N. Welch Manufacturing Company and Welch Spring Company, practically one concern. They have seven factories at Forestville and Bristol, employ 400 hands, and have four dams on the Pequabuck; they can realize full capacity from their water-wheels perhaps six or eight months in the year, but consider steam the principal power.

THE SCANTIC RIVER.

This stream joins the Connecticut river from the east a couple of miles above the mouth of the Farmington. It rises a few miles above the Massachusetts boundary, running thence southwesterly into Connecticut, and drains a total area of 118 square miles. The fall of the stream is not large, and in the main portion of its course seems to be mostly taken up. The section constituting the lower basin has a slightly broken and undulating surface, but as a whole is comparatively flat. The soil is generally light and sandy, though clayey in some sections and more or less alluvial along the streams; it has been quite thoroughly cleared of timber, and is well cultivated in tobacco and corn.

At intervals along its course the bed displays ledge rock, usually red sandstone, and much of it shaly and inferior in character. The dams at Scantic, Hazardville, and Scitico are built upon these ledges, and the same stone is used in the construction of some of them. For a third of a mile above the Scantic dam the bed is of rock, and this again crops out just above the mouth of Broad brook. Where the stream passes through meadows it is flat and winding, the bed composed of sand and clay, and the banks are alluvial and low, rising from 4 to 8 feet above low water. In those sections it is therefore impracticable to build high dams without flowing considerable meadow-land, which, between Scantic and Hazardville, has been valued at $100 per acre, though it is probably somewhat lower now. The volume is tolerably well sustained in the dry season, though less so, as some claim, than formerly, when the timber had not been so much cut away. The drainage basin being rather flat and its surface receptive of water, the stream is not seriously affected by ordinary rains. A rise of 3 feet on the roll-way of the Scantic dam, about 100 feet in length, is considered large. The effect of a heavy rain at the headwaters is ordinarily felt forty-eight hours later at the mouth; a heavy spring rain brings the stream up in half that time, and in the great storm of October, 1869, it reached a very high stage in twelve hours. It commonly runs lowest in August. General Ellis gives the least discharge as 35 cubic feet per second, and the mean discharge 139 cubic feet per second.

The Scantic river is without any storage reservoirs, properly so called, though the mill-pond at Somerville is reported to be of good size; it would be possible to obtain a large flowage at other points, but on account of submerging valuable farming-land the plan would be expensive. It is practicable to build a dam 20 feet high at the site of the present one at Scantic, near the mouth, and the owner of the latter roughly estimates that it would give a flowage of 100 acres.(*b*) Again, a dam might be built at Scitico to give a very large flowage, but the pond would set back over the Hazard Powder Company's upper privilege.

The Connecticut Central (*c*) railroad crosses at Scitico, some 12 miles by general course above the mouth, and below that point runs parallel to the stream at a distance of a mile or a mile and a half from it. Ascending from the mouth to Scitico the water-privileges are, in order, as follows:

1. At Scantic village, 3½ miles from the mouth, is N. S. Osborn's saw-, grist-, and plaster-mill. The privilege has been in use since 1729, and for a hundred years in the present family. Upon a rock ledge rests the dam, a log

a As nearly as can be learned there are 17 on the main stream and South branch.

b This plan would involve purchasing the lower privilege at Broad Brook, occupied by a grist-mill.

c Leased to the New York and New England railroad, and by it denominated "Springfield Division".

structure, with the mill at one end. A fall of 5½ feet is obtained, under which are run five tub-wheels, rated at 15 horse power each. For five months in an average year they can all be run at full capacity, with a wastage at the same time on the dam, but in an extremely low stage only one wheel can be run without drawing down the pond.

Below the dam the stream is about 40 feet wide, and thence to the mouth has a fall, in low water, of 18 feet. In high stages the Connecticut river sets back to the dam, and in exceptionally high floods, such as that of 1854, has been known to cover it entirely from sight. In some years no trouble is experienced from backwater, while in others it hinders more or less for four or five weeks.

Estimate of power at Scantic village.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*5½ feet fall.*	*20 ft. fall. (a)*
Low water, dry year	11	11	12	10	44	104	25	2.84	16	57
Low water, average year							40	4.54	25	91
Available 10 months, average year							45	5.11	28	102

a See preceding remarks.

2–4. From Scantic to Hazardville, a distance of 6 miles, the stream has a meandering course through meadows, and is mostly smooth water. At Hazardville is the extensive property of the Hazard Powder Company, embracing a total fall of 46 feet, divided into three privileges, each improved by a dry-stone dam. Canals, enlarging at various points into ponds of moderate size, convey water from the dams to the different mills, which are much scattered. The company also owns two privileges at Scitico, one of them in use for its works and one unimproved. The aggregate number of wheels in use on all the four utitized privileges is twenty-four, with an estimated total of about 300 horse power; 200 horse-power of steam is also employed. In an average year the wheels can be run at full capacity for about eight months.

5. Paper-mill privilege, with 12 (?) feet fall.

6. Privilege at Scitico, occupied by Spencer & Charter's 4-run grist-mill. The dam is of horseshoe shape, and is a fine cement-masonry structure, about 80 feet long, 20 feet wide at the base, and nearly as wide at the top. A fall of 12 feet is in use.

7. Fall of 9 feet, unimproved except by the remains of some old work; owned by the Hazard Powder Company and held for its own use.

8. Hazard Powder Company's upper privilege, 16½ feet fall.

Broad brook is a small stream joining the Scantic at Broad Brook village. It has but slight value for power, and is used by only one concern of importance—the Broad Brook Company, manufacturer of fancy cassimeres, and running 16 sets of cards. There is a pondage of about 8 acres above the dam, but there is no storage reservoir on the stream for improving its dry-season flow, although it is said that one could be built at Melrose. The Broad Brook Company runs its mill principally by steam, but it has two water-wheels, each of 60 horse-power, operating under 24 feet head. About 30 horse-power in all can be obtained in the lowest stage of water, but the full power of the wheels is not realized more than one month in the year. There is a small grist-mill below and there are two saw-mills above on the stream.

THE WESTFIELD RIVER.

The main branch of the Westfield river rises in the town of Savoy, in the northeastern part of Berkshire county, Massachusetts. It flows thence southeasterly through portions of Hampshire and Hampden counties, and empties into the Connecticut at Springfield, having a total length of 55 miles. Twenty-two miles from the mouth it receives the West branch, and 2 miles above, the Middle branch. The Boston and Albany railroad follows up the main river from Springfield to Huntington, and then continues up the course of the West branch; the New Haven and Northampton railroad crosses at right angles to the course of the stream, at Westfield, but otherwise the drainage basin of the river, comprising 514 square miles, is without railroad facilities. The following data will give some idea of the slope of the West branch and a portion of the main stream:

Table showing the fall in the Westfield river.

Locality.	Elevation of water-surface above sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Feet.	*Feet.*	*Miles.*	*Feet.*	
Becket, West branch	1,200				Boston and Albany Railroad profile.
		628	9	69.8	
Chester, West branch	572				Do.
		217	7	31.0	
Huntington, main river	355				Do.
		123			
Top of Salmon Falls dam, Russell	232		11	20.3	Report of committee for protection of Westfield from floods.
		100			
Top of Horton's dam, Westfield	132				
		39			
Top of canal company's lower dam, Mittineague	93		11	8.5	
		55			
Mouth of river at low water	38				

The country drained by this river is very hilly, and toward the headwaters is even mountainous, with many steep and rocky slopes; and as the storage reservoirs are neither numerous nor very large, rainfall quickly finds its way into the main water-courses and produces rapid fluctuations in volume. Low water lasts usually from the middle of July to the middle of September. There is often a period of high water from the first to the middle of October, while the spring rise comes in March or April. The ordinary spring-freshet depth on Chapin & Gould's dam, below Huntington, about 200 feet in length, does not exceed 6 feet, though that is sometimes also reached in a summer storm; but on December 10, 1878, water poured over the dam 12 feet deep, flooded the lower part of the mill, and brought down stream huge masses of rock, tons in weight. The circumstances of this memorable flood were, briefly, as follows: On the date of its occurrence there was already on the ground a moderate depth of snow, not exceeding 6 or 8 inches. It rained steadily during the day, but the falling water was absorbed and held by the snow, without either running off or penetrating the frozen surface underneath, and the streams gave no indication of a dangerous rise. At four or five o'clock in the afternoon, however, the weather changed and became very warm. The snow melted with great rapidity, the ground was soon bare, and by ten o'clock at night an immense volume of water was pouring down the channel of the stream. The flood was not of long duration, its height being maintained but an hour or so, but great damage was done along the whole course of the Westfield river; dams were injured, the railroad was overflowed and washed out in places, and farms and villages were inundated. Of the main portion of the river there is nothing especially important to be said as regards ice. Surface-ice is sometimes held back in the mill-ponds, and sometimes runs out when yet thick and strong. It is well broken up in going over the dams, and does not appear to cause serious trouble, although it occasionally gorges and produces a temporary set-back in the river.

It is difficult here, as with the other streams that have been described, to get any accurate data concerning the reservoirs, but such facts as could be obtained as to their location and size are given below:

Principal lakes and reservoirs in the Westfield River basin.

Name.	Locality (town).	Approximate area.	Remarks.
		Acres.	
Windsor pond	Windsor	107	Tributary to main river. Area as given by H. F. Walling—see Appendix B, *Report of the Massachusetts State Board of Health*, 1873.
Reservoir owned by L. L. Brown Paper Company.	Near Cummington village	200 (?)	Power used at outlet. Area as stated by officer of company at South Adams. Tributary to main river.
Norwich pond	Huntington	128	Tributary to main river, but not now in use as a storage reservoir, though formerly so employed. Area as given by Walling.
Center pond (reservoir)	Becket	163	Tributary to West branch. Area as given by Walling.
Yokum pond (reservoir)	do	118	Do.
A new reservoir	Probably in Becket		Tributary to West branch, and said to be larger than either Center or Yokum pond.
Wheeler reservoir	Becket	100	Tributary to West branch. Area as given by Walling.
Rudd pond (reservoir)	do	96	Do.
Church's reservoir	Middlefield (?)		Tributary to West branch.
Long pond	Blandford	150	Tributary to Little river. Area as given by Walling.
Blair pond	do	215	Do.
North Meadow pond	do	80	Do.
Congamuck pond	Southwick	589	Outlet through Great brook. Area as given by Walling.

General Theodore G. Ellis has given the least discharge of this river as 500 cubic feet per second.(*a*) This is a high discharge, corresponding very nearly to a cubic foot per second per square mile of drainage area, and, judging also by the experience of the mills on the river, seems considerably too large. In the same report, written in 1874, General Ellis placed the greatest discharge at about 28,600 cubic feet per second, but subsequently, in the great

a Surveys and Examinations of the Connecticut River, page 55.

freshet of December, 1878, this figure was certainly much exceeded. In his report upon a plan for protecting the town of Westfield from damage by floods, Mr. Hiram F. Mills, of Lawrence, gave the greatest flow of the river during the freshet alluded to at 53,000 cubic feet per second on the Salmon Falls dam and 46,000 cubic feet per second on the Agawam Canal Company's dam.

Ascending the Westfield river, smooth water continues from the mouth to within a quarter of a mile or so of Mittineague, where is located the first dam. A rocky shoal then begins and stretches up past the village, being interrupted only by the fall and slack-water of the dams. The banks are rather high and steep, and in places rise vertically from the river, being composed of a shaly red sandstone which crumbles away with exposure.

The lower privilege at Mittineague is owned by J. L. Worthy. A low timber dam, resting on a rock ledge, runs diagonally across the river, with a mill at each end. On the south side power is leased to the Worthy Paper Company, manufacturers of fine writing- and ledger-papers. The tail-race on this side runs for an eighth of a mile down stream beside the bank, in order to gain advantage of the shoals below the dam. The fall on the privilege is nominally 10 feet, but is practically only about 8 feet much of the time, the tail-race having filled up somewhat. At the north end of the dam is a 2-run grist-mill owned by Mr. Worthy and leased to H. C. Bouton. The paper-mill runs part of its machinery 10 hours and part 24 hours per day. It has the first right to water, and throughout ordinary years has a sufficient supply, but for two months in the summer of 1882 could only run at two-thirds capacity, and the grist-mill was shut down altogether during that time. Backwater from the Connecticut troubles here during freshets, and especially when the two streams are high at the same time. The ordinary depth of backwater on the wheels from freshets is perhaps 2 feet, and 6 feet is reached in extreme cases; the former amount may last three or four days, but the paper-mill is never entirely stopped by backwater for more than two days. Ice-gorges sometimes form in the river below and produce a temporary set-back, but hinderance from this source is neither serious nor lasting.

The Agawam Canal Company's privilege, in the same village, succeeds the one just described. A timber dam, with roll-way 457 feet long and 18½ feet high, extends across the river half a mile or more above the mills. A canal runs down the north bank past the rapids, and supplies, in order, the Southworth Company, manufacturers of fine writing and ledger paper; the Agawam Canal Company, owners of the power and manufacturers of cotton goods—sheetings, shirtings, and drillings; and the Agawam Paper Company, engaged in the manufacture of fine writing paper and bristol-board. Backwater from this dam reaches only about a third of a mile, and is succeeded by a second dam, a log structure with roll-way 358 feet long and 6 feet high, which sets back the stream perhaps 2 miles with an average width of say 300 feet. No power is used here, and the reservoir merely serves to pond water for the use of the mills below.

Including both falls, the canal company owns in all about 39 feet, 6 feet at the reservoir dam and 33 feet at Mittineague. At the latter point the fall from the canal to the river varies from 29 feet at the Southworth mill, to 33 feet at that of the Agawam Paper Company. The canal company has leased 132 horse-power to each of the other two companies, and itself runs wheels having an aggregate rated capacity of 350 horse-power. There is good building-room near the railroad station for another large mill, but unfortunately power is lacking, and the privilege is, practically, fully developed; an additional mill could not be sure of water for more than six or eight months in some years. For four years previous to the summer of 1882 there was constantly enough water for all the mills, but during that season the supply ran short and caused more or less stoppage at the lower mill. For two months it was necessary to rely largely upon the reservoir; for one month it did not fill at night, and the water-surface was at times from 26 to 32 inches below the crest of the dam in the morning. The practice is to draw down the reservoir not more than 45 inches, as below that level sufficient water is not obtained to be of much assistance.

Anchor-ice runs in the canal and bothers somewhat by clogging the wheels, but they are never stopped more than two or three hours from that cause. As has been mentioned concerning other New England privileges, so here trouble has occasionally been experienced from the canal having been drawn down in winter so that the thick surface-ice settled; the water afterward rose on top of the ice, and, freezing, formed so thick a mass as seriously to interfere with the flow.

At Mittineague the land rises from the river to hills of moderate height, and then spreads out gently undulating. It is fairly cultivated in tobacco and corn, and shows occasional patches of timber. Above the village the stream comes through a range of hills, and then, for a long distance above, its course lies through a level plain, in which is Westfield, the most important place on the river. The stream appears to be generally quite flat in this section, and although the table of elevations, previously given, indicates a fall of 39 feet from the top of Horton's dam at Westfield to the top of the lower Agawam dam, or over 20 feet between the foot of Horton's dam and the top of the upper Agawam dam, this latter fall seems to be nearly all utilized in giving the stream a smooth, uniform flow without shoals of any importance; and diligent inquiry only elicited the opinion that there is no available privilege in this distance. It was stated that some years ago the Agawam company talked of raising its upper dam 4 feet, and that objection was made by the owners of the lower privilege on Little river from fear of backwater.

The dam at Westfield is close by the Boston and Albany railroad station, and near the foot of what were formerly called the "Half-mile rapids", a series of rocky shoals. It rests mainly upon a rock ledge, which also

extends out under the north bank, but which suddenly drops away on the south side of the river before reaching the bank. The old dam rested entirely on the ledge, but after the flood of December, 1878 (*a*) it was extended at the south end in beyond the ledge, over a quicksand bed, and there rests upon a foundation of piles. The present length of the roll-way is stated to be about 450 feet and its height 6 or 7 feet; it is built of logs. The mills and shops are located at either end of the dam, and are of small size, there being two or three establishments in a single building. On the north side are a saw-mill and planing-mill, a 4-run grist-mill, a machine-shop, the Acme Whip Company's works, the Warren Thread Mill, the Pierce Steam Heating Works, and a concern for the manufacture of cotton-waste; on the south side are two shops manufacturing, respectively, whip-snaps and whip-stocks.

This privilege is owned by Mr. Samuel Horton, who rents power to the various manufacturers. The fall is about 10 feet, and the effective horse-power is estimated at from 300 to 500 for the greater part of the year; 150 or 200 horse-power is now in use. The pondage above the dam is not large, being confined within the natural banks of the stream. In the dry season the supply of water is liable to be very irregular; when the mills farther up stream are allowing their ponds to fill, scarcely any water comes down, and the power sinks very low for a time. Such occurrences are exceptional, however, and aside from those times the available power may be estimated as below:

Estimate of power at Horton's privilege, Westfield.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*
Low water, dry year	12	13½	14	10½	50	360	80	9.09	90
Low water, average year							140	15.90	160
Available 10 months, average year							210	23.86	240

For 3 or 4 miles above Westfield the course of the river continues through a flat country, with no woods or consequence, but settled and cultivated; the bed is gravelly, the banks are of only moderate height, and there is but slight fall to the stream. Near what is known as the "Four-mile house" it issues from the mountains, and it is said that by building a dam just above this point and running a canal out upon more open ground a fine privilege could be developed. The fall in this section is owned by various parties having land adjacent to the course of the stream and the amount available for such a power as has been mentioned would of course be governed by the height of dam and length of canal. Between the foot of the Vernon property at Salmon Falls and the top of Horton's dam at Westfield there is an unimproved fall of 54 feet, the power of which can be judged by comparison with the estimate made for Horton's privilege.

For a mile above the Four-mile house, to Salmon Falls, the stream lies at the bottom of a deep valley, the mountains rising on either side with steep and rocky faces. The Boston and Albany railroad and a carriage road follow the valley, high up from the stream, the former on the north and the latter on the south side. The space is too contracted for the improvement of water-power in this portion, but at Salmon Falls, 5 miles above Westfield and 2 miles below Russell, the valley widens out somewhat and the stream foams down over great outcropping masses of granitic rock.

On the upper part of the falls a heavy masonry dam, the stones tied together with iron dogs, runs in an irregular line across the river from one ledge to another, the mill being built close to the dam on the south bank. The privilege is owned by Vernon Brothers, of New York, and is occupied by the Vernon paper-mill for the manufacture of all kinds of fine writing paper. The fall in use is 24 feet, and the proprietors also own an additional fall of 22 feet immediately below, extending to a pool at the foot of the falls. Five water-wheels, with an aggregate capacity of 540 horse-power, are in use, and in an average year can be run at full capacity about nine months. For the rest of the time the supply is more or less short, but it is estimated that 240 horse-power can be obtained 10 hours per day in the lowest stage of the river. A 350 horse-power steam-engine is run during low water. From November, 1881, to July, 1882, the works were run entirely by water-power, but from that time on to at least the middle of September, when the stream was visited, steam had to be used as auxiliary power. The pondage here is not great, but is sufficient to run the mill for several hours without any assistance from the stream during that time. Two hundred hands are employed, and part of the works are run 10, and part 24, hours per day.

Between Salmon Falls and Huntington the rise continues rapid, amounting to 123 feet in the distance named; the bed is gravelly or rocky, and the valley is much of the way narrow. It is probable that several good privileges might be developed here. Perhaps three-quarters of a mile above Salmon Falls there are gravel shoals, and on the south side of the stream the land rises gradually from the immediate bank, which is of fair height.

About a quarter of a mile below the present depot at Russell the Boston and Albany railroad formerly crossed the river; it then continued, say three-quarters of a mile, up the west bank and recrossed. At the lower crossing a

a During that flood the water rose 14 feet above the crest of the dam. The roll-way was afterward made 80 feet longer in order to give greater length of overfall and thus to diminish the rise bove the dam in future freshets.

granite ledge rises 20 feet above the water and extends across the river, forming most of the way a natural dam. Three piers and the west abutment of the old bridge still remain. At the road bridge, a quarter of a mile up stream, the river is from 175 to 200 feet wide. It continues rapid down to the ledge, and probably falls 6 feet in the last 600 feet. Approaching the ledge it contracts, runs between two adjacent bridge-piers, and at one point, indeed, is at low water confined to a width of 10 or 15 feet. There is good building-ground immediately below on the east bank, adjacent to the railroad, and possibly the ledge itself could be conveniently used in part for foundation. The present railroad grade is about 23 feet above low water at the old bridge site, and in improving the privilege it would be necessary to provide a sufficiently long roll-way to guard against a rise on to the track in high water, but probably a dam 10 or 12 feet high could be raised without any danger. Or, if desired, a dam could be built somewhat above, and a canal run down the west bank. Immediately below the natural dam there is smooth water for some distance.

Estimate of power one-fourth of a mile below Russell station.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*	15 *feet fall.*
Low water, dry year	325	70	7.95	80	120
Low water, average year		120	13.63	140	200
Available 10 months, average year		190	21.58	220	320

The upper of the old railroad crossings, three-quarters of a mile, more or less, above, has also been suggested as a good site for a dam. The bed and banks are there gravelly, the latter rising 25 or 30 feet above low water, and the railroad track is about 25 feet above the stream on the east side. If a dam of good height were built there and a canal run down the west bank, advantage might perhaps be taken, part of the way, of a depression inside the old railroad grade; but if carried far the canal would be likely to encounter some rock.

Between Russell and Huntington, and about 2¼ miles by road below the latter point, is Chapin & Gould's paper-mill, employing 120 hands in the manufacture of blank-books. The dam has a roll-way about 200 feet long, and runs out upon massive ledges which here fill the stream. It is in two sections, which from the shores make an angle with its vertex down stream. Formerly the structure was entirely of stone, but in the flood of 1878 it was partially carried away, and one-half has since been replaced by a crib-work bolted to bed rock and filled with loose stone. The fall on this privilege is 21½ feet, and the wheels used have an aggregate capacity of 316 horse-power. The mill runs 24 hours per day, and can be operated at full capacity by water-power ten or eleven months in an average year. Messrs. Chapin & Gould also own, and hold for their own use, 18 or 20 feet of fall immediately below this privilege.

The next power is at Huntington, a short distance above the mouth of the West branch. It is owned and occupied by the Chester Paper Company, employing 70 hands in the manufacture of writing paper. The dam is built upon a rock ledge most of the way across, but the ledge drops away before reaching the east bank, and there a portion of the dam and the east abutment rest upon quicksand. The structure is a log crib-work with stone filling. It was originally started as a stone dam, but the foundation proving unsuitable the plan was changed and the dam built as stated. It has a straight roll-way about 266 feet long between abutments; the height at the crest is 14 feet, from which point there is a slope both ways, the down-stream slope being prolonged by an apron making a small angle with the horizontal. The width at base, from the foot of the back slope to the end of the apron, is about 50 feet. The main part of the dam was built in 1870, but the flood of 1878 carried away the east abutment and made it necessary to extend the roll-way 60 or 70 feet. The mill was also injured at that time, and a three months' stoppage of work was forced. The original dam cost $14,000, and the repairs made in 1879 cost $8,000. The east abutment is now a crib-work. The west abutment, which rests upon rock and is upon the same side of the river as the mill, is heavily built of cemented masonry, measures, at the top, 11 feet with the stream by 20 feet inshore, and rises about 10 feet above the crest of the dam. It is continued in shore and up shore by a masonry bulkhead and river-wall, the former pierced by three gate-openings each about 2½ by 4 feet in size. The pond is of moderate size, and flows but very little beyond the natural banks of the stream. At the mill, which is immediately below the bulkhead, a fall of from 14 to 16 feet is obtained, and old wheels, estimated to furnish in the aggregate about 140 horse-power, are run. This amount of power can be realized, it is thought, 24 hours in the day for nine months in the average year; the flow is quite variable, however, and during the two months of July and August, 1882, the works could not be run at more than one-fourth capacity a part of the time.

The Chester Paper Company owns the right to a reservoir on Norwich hill, in the town of Huntington. It is a natural pond of 100 acres or more, raised by a dam so as to flow not over 200 acres, and could be drawn down 8 or 10 feet. A dispute with the county commissioners as to the character of certain improvements in the dam caused the use of this reservoir for storage purposes to be given about the year 1880 or 1881. It could be relied upon to fill only once during the year. It is a general opinion, and undoubtedly a correct one, that the main branch of the Westfield river might be well reservoired.

Immediately succeeding the privilege last described, and situated close to the village of Huntington, on the main stream, is a power owned, two-thirds by W. P. Williams and one third by H. E. Stanton. It is used for the manufacture of ax-handles, and by a saw-mill and a grist-mill. When all the works are running it is estimated that about 75 horse-power is in use, and in very low stages of the river there is no surplus water. The dam is a log crib-work with stone filling, has a sloping face, and a horizontal apron 11 feet wide. It rests partly on ledge rock and partly on gravel; the east abutment is of crib-work, and the west, next the mill, of stone. The dam is 260 feet long between abutments, 8 or 9 feet high, 36 feet wide at the base, including the apron, and was built in 1875 at a cost of $9,000. The flood of 1878 washed around the east abutment, and 75 feet into the adjacent high gravelly bank, but did not injure either the abutment or the dam. Immediately from the gate at the west end of the dam water is carried through a wooden tube of 4 feet internal diameter, first to the grist-mill and then to the saw-mill. The present fall is about 10 feet, but by excavating the tail-race it is to be increased to 12 feet. The freshet-rise on the dam is ordinarily from 3 to 5 feet, but in December, 1878, it was 12 feet.

Ascending the main or East branch of the Westfield river above Huntington the fall is found to be rapid and constant; it is said that a railroad survey has shown the average descent from West Chesterfield to Huntington, a distance of 12 or 14 miles by general course, to be 18 feet per mile. The river-bed is composed of ledge rock at many points, and elsewhere of gravel and bowlders. The banks are variously of gravel or rock, and are of good height. The flowage would not commonly be large, although such might be obtained in places by a high dam. The valley is frequently narrow, with high steep banks to the stream; but there are numerous intervales where the hills recede and the river is bordered, usually on one side only, but sometimes on both sides, by narrow meadows. The immediate valley is sparsely settled, and often contains the poorest land. The hill-slopes rise on either side abrupt and rocky, well wooded, and where cleared are mainly devoted to pasturage. But ascending out of the lower valley the country stretches away, still hilly, but with long, gentle, and beautiful slopes of fine farming land. Grass, corn, potatoes, and stock are principally raised. In the vicinity of Huntington chestnut and red-oak are the chief varieties of timber. Chestnut continues for 10 miles up the main stream and 4 miles up the Middle branch, and is succeeded by hard wood and hemlock above on both streams. In the neighborhood of West Chesterfield beech, birch, and maple are the more common trees.

Freshets and ice-runs are probably more noticeable on this part of the main river than toward its mouth, where there are more dams and a greater storage. The stream rises from 6 to 12 hours after a heavy rain, and then rapidly recedes. An important disadvantage to the use of water-power in this section is the absence of railroad facilities, the Boston and Albany railroad leaving the main river at Huntington and running up the West branch.

There is no power in use between West Chesterfield and Huntington, although there is a large fall, of probably over 200 feet, in this distance. A considerable portion of this might doubtless be put to use, and a few of the more prominent sites will here be considered.

At Norwich Bridge, a mile and a half above the point of union with the West branch, a rude dam of cobble-stones years ago diverted water into a race which ran 250 feet down the east bank to a satinet-mill. The dam was carried away in an October freshet and the power went into disuse. The location is fair, but it would not be practicable to build any but a low dam, because the banks are low above. The river is about 140 feet wide at Norwich Bridge, and between that point and the next privilege to be described the Middle branch comes in.

The next power is owned by Mr. S. S. Stowell, who resides a short distance below Norwich Bridge on the east side of the river. The stream cuts through a gorge, and is hemmed in by rocky walls rising almost vertically from 30 to 50 feet; it dashes through this cut with rapid fall over rock ledges. Every facility is offered for a dam, strong and secure, of almost any desired height; while above and below the gorge the hills recede so as to offer, in the one case large flowage, and below, a fine site for canal and buildings. Two rocky shoulders projecting on either side of the river present natural abutments for a dam, which would run diagonally across the stream, with a length of probably from 200 to 250 feet. A canal could then be carried out on the west bank a little way, that side of the river being the more favorable for building; some rock-blasting would very likely be necessary. Mr. Stowell's privilege is 2½ miles by road from Huntington, and certainly possesses fine natural advantages. One-half or three-quarters of a mile above Stowell's privilege there is another fine site. The river here runs south and then bends sharply to the west. The east bank is gravelly, and rises steeply from the water 25 feet to the highway. A short distance back from the water the west bank also rises to a hill. A dam of good height could be built. The canal would naturally be carried on the west bank, and would soon strike a broad flat, surrounded in part by the river-bend and with abundant building-room. The river-bed at this point is covered with gravel and bowlders, and is about 150 feet wide between banks.

At Knightville, 4 miles above Huntington, the river runs for several hundred feet between almost vertical cliffs, with swift current and rapid fall. These cliffs rise from 30 to 50 feet at once from the water, and are composed of strata of mica-schist, dipping to the westward at an angle of at least 75 degrees. The stream varies in width from 50 to 75 or 100 feet. A little below the foot of the gorge a ledge of gray granite runs diagonally across the river and affords a splendid site for a dam. The rocks project from 3 to 7 feet above low water, and so completely close the channel as to cause an abrupt pitch of about 2 feet. At the west end of the ledge the bank rises, rocky and nearly vertical, 30 feet or so. The east bank also shows ledge rock close to the water, but farther back it is

covered with a gravelly soil and has a gentle rise. A high dam could be built here, and a mill located either at its east end or upon a short race to be run down that bank. The valley is sufficiently open to accommodate a mill of good size and a moderate number of houses within a convenient distance, but the location is not suited to a large village. A number of years ago the power here was in use by a saw-mill, a grist-mill, a bedstead-shop, and a large factory for the manufacture of children's carriages and sleds. The owners at that time had not much capital, and the power was never fully improved. The dam was built upon the granite ledge which has been mentioned, and was a wooden structure; it was partially destroyed in 1869, and two years later the remainder was swept away. At present two-thirds of the privilege is owned by Alonzo Clark, of New York city, and one-third by Webster Herrick, of Northampton, Massachusetts. The available fall owned is stated at 21 feet, the power corresponding to which may be estimated as below:

Estimate of power at Knightville.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*21 feet fall.*
Low water, dry year	$11\frac{1}{2}$	13	$13\frac{1}{2}$	10	48	158	30	3.41	70
Low water, average year							50	5.68	120
Available 10 months, average year							80	9.09	190

At the road bridge shortly above Knightville the river measures from 90 to 100 feet in width. A half-mile or so above that village a dam could be built, though the banks are not especially favorable, and a canal could be run down the left bank to a fine open spot. Above this point the highway is low and near the river, and any but a low dam at the locality mentioned would probably cause it to be overflowed during high water.

Within about 5 miles of West Chesterfield the valley grows narrower, and building-room is not so abundant as below. Some 4 (*a*) miles below the village, and close by the carriage-road, a rock ledge crosses the river between high banks. A canal could be extended a short distance on the right bank, and room would be obtained for a mill of moderate size, but the space is rather limited. Below the ledge the left bank is alluvial and sandy in places. The river is here from 75 to 100 feet wide, and the rock strata are, as elsewhere in this section, nearly or quite vertical. The privilege is a fairly good one.

Just above this locality there is an old log dam running in a V-shape across the stream on a ledge. It is leaky, and in poor condition generally; the north end is broken away, and all the water of the stream passes through the breach and through the old dry-stone bulkhead immediately adjacent. The mill is gone, and there is but little building-room close to the dam, though by carrying a race 100 feet down the bank abundant open space would be reached where a valley puts back from the river. The fall over the dam is probably not more than 6 feet.

About a mile below West Chesterfield the stream is inclosed for a considerable distance by smooth vertical walls of solid rock, rising on the west side 20 or 25 feet from low water, and still higher on the opposite side. The river is perhaps from 100 to 150 feet wide, and the west bank is succeeded by open ground suited to building. Many years ago the river is said to have been dammed at this point and power to have been used by a woolen-mill and two saw-mills, but they were all carried away in a great flood in January, 1839. The stream is so confined by the vertical walls which hem it in that a dam of any considerable height in the gorge would probably cause a dangerous rise during high freshets. In December, 1878, the river is said to have risen here 34 feet above low water and to have overflowed its high banks.

The last privilege to be noticed is in West Chesterfield and is owned by Seth A. Healy. A V-shaped log dam extends across the river, with dry-stone abutments, and a roll-way about 150 feet long. A race perhaps a third of a mile long runs down the east bank to a small factory, where are made plane-handles, saw-handles, and gun-tubes. The fall on the privilege is stated to be 17 feet.

No examination was made farther up this stream. There is said to be no other power in use before reaching Cummington, where there is a paper-mill, with some other concerns of small size. At West Chesterfield the ordinary spring-freshet rise, where the river runs freely, is about 4 feet; but in December, 1878, there was a depth of 12 feet on the dam, the banks were flooded, and much damage was done. Ice of an ordinary thickness of about 2 feet runs down the stream in spring, and occasionally gorges in this section, though not often.

a These distances were estimated, and may not be accurate.

Principal water-privileges on the Westfield river, from West Chesterfield to the mouth.

Locality.	Drainage area.	Fall.	Theoretical horse-power. Low water, dry year.	Low water, average year.	Available ten months, average year.	Remarks.
	Sq. miles.	*Feet.*				
West Chesterfield	109	17				Power used, in part at least.
One mile below West Chesterfield (*a*)			*b*2.27	*b*3.98	*b*6.82	Rocky gorge.
Four miles below West Chesterfield (*a*)	116		*b*2.27	*b*3.98	*b*6.82	Has log dam, say 6 feet high.
Half-mile above Knightville (*a*)			*b*3.41	*b*5.68	*b*9.09	Good site.
Knightville (*a*)	158	21	70.00	120.00	190.00	Power formerly used.
Say 3 miles above Huntington (*a*)			*b*4.54	*b*7.95	*b*13.63	Good site.
Say 2½ miles above Huntington (*a*)			*b*4.54	*b*7.95	*b*13.63	Stowell's privilege. Fine power.
Norwich Bridge (*a*)	220		*b*4.54	*b*7.95	*b*13.63	Formerly used. Small power.
Huntington		12				Privilege owned by W. P. Williams and H. E. Stanton. In use by saw-mill, grist-mill, and ax-handle factory.
Do		14–16				140 horse-power in use by Chester Paper Company.
Say 2½ miles below Huntington		21½				316 horse-power in use by Chapin & Gould's paper-mill.
Do		18–20				Owned by Chapin & Gould. Not utilized, but reserved for their use.
Say ½ mile above Russell station			*b*7.95	*b*13.63	*b*21.58	Old Boston and Albany railroad crossing.
Say ¼ mile below Russell station	325		*b*7.95	*b*13.63	*b*21.58	Old Boston and Albany railroad crossing. Rock ledge and good site.
Huntington to Salmon Falls		82±	650.00	1,120.00	1,770.00	Total amount of undeveloped fall.
Salmon Falls	340	24				540 horse-power in use by Vernon paper-mill.
Do		22				Not utilized. Owned by Vernon Brothers.
Say 4 miles above Westfield	349		*b*9.09	*b*15.90	*b*23.86	Stream issues from mountains.
Salmon Falls to Westfield		54±	490.00	860.00	1,290.00	Total amount of undeveloped fall.
Westfield	360	10	90.00	160.00	240.00	Horton's privilege; from 150 to 200 horse-power in use.
Mittineague		0				Reservoir dam. No power used.
Do		33				Utilized for paper and cotton manufacturing.
Do		8–10				Utilized by paper-mill and grist-mill.

a In the sites here mentioned it is not pretended to embrace all that might be utilized, but only some of the more prominent ones. As previously stated, there is probably a fall of over 200 feet between West Chesterfield and Huntington. Its exact amount is uncertain; none of it is in use, and its division into privileges must depend upon circumstances.

b Per foot fall.

Middle branch of the Westfield river.—The Middle branch rises in the town of Peru, flows thence southeasterly between Worthington and Middlefield and through Plainfield, joining the main river a mile or two above Huntington. It drains 54 square miles. This stream was examined for about 8 miles above its mouth. In general features it is not unlike the upper part of the main river. The valley is shut in by high hills, well wooded and, where cleared, mainly devoted to pasturage. The width between the bases of the hills is, in the lower valley, perhaps half a mile in places, but farther up stream it seldom exceeds a quarter of a mile, and at times the hills rise on either side at once from the water's edge. Their slopes are, generally speaking, steep, and frequently very rocky. The narrow strips of meadow-land bordering the stream are devoted to grass, corn, and potatoes, and along the lower course sell at about $25 per acre.

So far as this branch was examined it differs from the main stream in not running through the narrow cañon-like gorges such as are found along the latter. There is no difficulty in finding banks of good height, but there are also many places where, on one side at least, the land immediately bordering the river is low. The carriage-road now and then runs along these low places, and would be overflowed by raising the water-surface much. The fall is rapid, especially in the upper waters, and on that account and because of the narrow character of the valley a large pondage would not in general be practicable; still it could doubtless be obtained at points by a high dam at the foot of an intervale and by flooding back over good meadow-land. The bed and banks are gravelly or rocky, and the former displays many bowlders; here, as on the upper main river, the rock strata are almost vertical, dipping a little north of west.

A large amount of fall remains undeveloped, and though the stream has some good natural advantages for power its value is lessened by lack of any railroad facilities. At present it is not supplied by any storage reservoirs, and the volume runs very low in a dry season; but it is said that reservoirs are practicable on the upper waters, and, in particular, that in West Worthington there is a large tract of swamp-land, estimated at several hundred acres, which could be flowed to good advantage. The manufacturing on this stream is mainly in small articles of wood, and years ago seems to have been more important than now, no less than five privileges, once improved, having gone into disuse on the portion of the stream which was visited.

Principal water-privileges on the Middle branch of the Westfield river.

Locality.	Owner or user.	Manufacture or kind of mill.	Fall.	Remarks.
			Feet.	
Town of Worthington	George H. Miller	Saw-mill and variety wood-work.	10	North Chester post-office. Uses 2 wheels and about 40 horse-power. Considers privilege good for 40 horse-power 8 months in an average year; during the remaining time it may run as low as 10 or 15 horse-power. During the summer of 1882 it ran below 10 horse-power, and for one month the pond did not fill at night; but there is considerable leakage at the dam. The latter is a framed and log structure on a rock ledge. It makes an angle down stream, and is 105 feet between abutments by 12 feet high. It was built about 1875, and cost approximately $500.
Say 8 miles from Huntington	Heirs of Elias Howe	Unoccupied		Formerly in use, and part of dam still remains.
North Chester	Herman Powers, of North Chester.	do	17½	Seven and a half miles from Huntington. Dam is about 100 feet long between abutments; 25 feet of this is stone, and the balance framed. It is 30 years old and needs replanking. Years ago woolen goods were manufactured here, and afterward cotton, and, in 1845, 150 hands were employed, but later on the mill was burned.
Do	Herman Powers	do	14	Good location, with rock ledge on left bank. The old log dam remains, but is decayed and half broken away. The mill stands in part, but is of no value.
Dayville	M. B. Prouty & Son	Shoe-pegs and 1-run grist-mill.	14–15	Log dam on ledge; 30 years old, about 120 feet between abutments and 7 feet high. Race several hundred feet to mill. Can run full capacity about 9 months in an average year.
Do	H. E. Day	Shoe-pegs, whip-butts, and saw-mill.	9–11	Five miles from Huntington. Low framed dam about 100 feet long, with level plank apron and dry-stone abutments, diverts water into a canal 15 or 20 feet wide and 200 or 300 feet long.
Dayville to Littleville		Fall unimproved		Stream 50 or 75 feet wide. Near Littleville there was a large power in use 30 years ago by a bedstead factory, which was afterward burned; 40 or 50 men were employed, and the buildings were of large size.
Littleville	B. B. Eastman	Whip-butts	3	Three saws are run, and about 12,000 butts are made per week. A log dam, 3 feet high and 90 feet long, turns water into a short race. The water-wheel was made by Mr. Eastman, and is novel because of its shallow depth and the small head under which it runs. It is of wood, is 4 feet in diameter and only 4 inches deep. It is estimated by the owner to furnish several horse-power, and will run the mill, it is claimed, when other mills on the stream can not run.
Do	Oliver Eastman	Wooden bowls and saw-mill.	8	Log dam over 100 years old; on rock ledge; about 100 feet long and 8 feet high. Perhaps 18 horse-power in use.
Littleville to Sloan's privilege		Unimproved		Distance of 1½ or 2 miles.
Not over half-mile from mouth	John Sloan, of Hartford, Connecticut.	Unoccupied	10½	Formerly used in the manufacture of wooden bowls. Old log dam remains; it is from 75 to 100 feet long and rests on ledge. The wooden flume is partly gone, but the old mill stands. Not in use for two years previous to 1882.

The stream rises and falls rapidly. Three feet on Miller's dam, the uppermost of those mentioned, is regarded as a large rise, and the ordinary depth does not exceed 18 inches; but in the great storm of December, 1878, the rise on the dam was 8 feet, and the banks were flooded. The dams below on the stream were injured more or less, and nearly all the bridges were swept away.

West branch of the Westfield river.—This stream possesses the two advantages over either of the other branches of the Westfield, of being skirted through almost its entire length by the Boston and Albany railroad, and of being well reservoired. Its fall is very rapid, and its bed is composed of gravel and bowlders, with frequent outcropping ledges. The immediate valley is seldom more than a quarter of a mile wide between the bases of the hills, and often these ascend at once from the stream. Their slopes may be described as in general steep, quite rocky, and fairly well wooded. There are occasional small villages along the stream, but the surrounding country is sparsely settled. Much of the timber has been cleared away and replaced by pastures, and to some extent by cultivated fields, on which corn and potatoes seem to be the chief crops. The rock of this section appears to be largely granitic, and along the valley are found deposits of quartz and feldspar in the pure state. The reservoirs are all on the headwaters, and nothing more definite could be learned about them than as follows:

The Bancroft company, at Middlefield, controls three reservoirs: Center pond is perhaps three-quarters of a mile long and a quarter of a mile or so in width; it is a natural pond raised by a dam, fills regularly every year, and can be drawn down about 10 feet. Yokum pond is of smaller size, a natural pond raised, can be drawn down 10 feet, but does not fill regularly. The third reservoir is a new one, made artificially by flowing a tract of swamp-land; it is the largest of the three, has an extended water-shed, fills readily, and can be drawn down 12 or 13 feet. It is stated that this reservoir can be raised 5 feet more, and can also be connected by a horizontal cut with Yokum pond, which is near at hand, so as to insure the filling of the latter. Another large tract of swamp-land was reported which might be flowed to good advantage, and which was considered somewhat as a site for the reservoir last described.

At Becket a company whose mill is not now in operation controls two reservoirs, known as Rudd pond and Wheeler reservoir.

On a side stream emptying just below the Bancroft mill, at Middlefield, Church Brothers are said to have a reservoir and to use power at the outlet for a woolen-mill.

Six reservoirs have been mentioned. Regarding the area of two of these no information whatever has been obtained; the remaining four, Center, Yokum, Wheeler, and Rudd ponds, have a combined area, as given by H. F. Walling,(a) of 477 acres.

Water-privileges in use on the West branch of the Westfield river from Middlefield to the mouth.

Locality.	Firm.	Manufacture.	Fall.	Remarks.
			Feet.	
Middlefield	Bulkley Dunton Company	News- and wall-paper	29	Low log dam with long race. Uses overshot wheel of 150 horse-power. Employs 20 hands.
Do	Bancroft Mill	Wall-paper, mainly	21	Cheap log dam roll-way estimated at 125 feet long and 7 feet high; water brought to mill through a long race. Uses overshot wheel of 110 horse-power, and can run at full capacity by water-power 10 months in an average year.
Chester	Timothy Keefe and Gurdon Bill owners of privilege.		12	Log dam, and race 150 feet or more in length. Two wheels used, of 40 horse-power each, and can be run at full capacity 9 or 10 months in an average year. J. Keefe makes bedsteads and Frank Grant & Co. make corundum wheels.
Do	Hampden Emery Company	Emery and corundum	10½	Log dam with log apron; roll-way say 140 feet long by 10 feet high. Uses 100 horse power, and can usually run at full capacity by water-power about 9 months in the year, but during the summer of 1882 the power is estimated to have fallen to from 15 to 25 horse-power much of the time.
Do	E. Wilcott owns privilege		10	Rude dam of cobble-stones, and race from one quarter to one-third of a mile long. Perhaps 10 horse-power in use. Wilcott makes toy whips in a small way, and leases power to Nelson & Judd for grinding quartz and feldspar.
Spar Hill, just above Huntington.	Chester Mica and Porcelain Company.			Grinds quartz and feldspar obtained from neighboring mines, and ships the product to be used in making porcelain and sandpaper. Has a log dam 70 or 75 feet long and 6 feet high, with sloping face 18 feet in length. Race several hundred feet long to mill.
Huntington	Highland Mill	Woolen suitings	14	Runs 5 sets of cards. Log dam with stone filling, and canal 500 feet in length. Has sufficient water 10 months in an average year.

Above Middlefield there was reported to be no power in use except by one or two small saw-mills in Becket. This portion of the stream has a bed of gravel, ledge rock, and bowlders, and a fall of 80 feet or more to the mile. The abrupt, rocky slopes quickly shed rainfall into the river, but the descent of the latter is so great that the water is quickly carried off, and freshets cause no serious trouble. Slight hinderance is experienced from anchor-ice in the races at Middlefield.

The privileges which are described in the preceding table of course include but a small part of the aggregate fall of the stream. According to the profile of the Boston and Albany railroad, there is a total descent of 845 feet from Becket to Huntington, of which probably not more than 15 per cent., at the most, is utilized. Much more fall might be improved than has been, but a considerable portion of the stream has but little value, because it is not easily accessible. About a quarter of a mile below its paper-mill at Middlefield, the Bancroft Company owns and holds for sale 30 feet of unimproved fall; this privilege has the benefit of the water from Church's reservoir. Thence down to Chester, in which distance the fall is probably in the neighborhood of 300 feet, there are no dams on the river. The carriage-road leaves the stream and makes a wide detour over the mountains; the railroad winds along in the narrow valley, crosses the stream frequently, and is without any intermediate stations, and the stream is too inaccessible to have any importance for power.

Little river.—This is an important branch joining the main river from the south between Westfield and Mittineague, and draining 87 square miles. Its lower course is through flat meadows, where it has low banks and slight fall. These meadows are well cultivated in corn; though low, they are out of reach of ordinary freshets from Little river, and it has overflowed them but twice in 20 years.

The first privilege above the mouth is that of the Westfield Power Company. A crib-work dam crosses the river, and has abutments of piling filled in with gravel. The dam is 297 feet long between abutments, 5 feet 8 inches high above the top of the mud-sill, and has an extreme width at base of 24 feet, including the apron; the front of the dam rests on a row of piles, and at the back a line of 3-inch priming prevents leakage. From the dam, water is carried, in an old feeder of the abandoned New Haven and Northampton canal, to the main canal and thence into Westfield, a total distance of about a mile and a half; a tail-race a mile or more in length returns the water to Little river. The power company owns three large brick buildings, and a smaller building of wood; in these it rents room and power to twelve different concerns. One of these makes coffin-trimmings, another emery-wheels, and the remainder are all engaged in the manufacture of whips, for which industry Westfield is well known to be the main center. The power employed is small, being obtained from a 60 horse-power steam-engine, and from an 18 horse-power water-wheel running under 10 feet head.

a Appendix B, *Report of the Massachusetts State Board of Health*, 1873.

The next privilege, only a short distance above the first dam, is occupied by Crane Brothers, manufacturers of fine ledger and all-linen paper. They own 20 feet of fall, 18 of which is practically available and in use. The wheels are of an aggregate of 200 horse-power, all of which is in use when it can be obtained, which is ordinarily about eight months in the year. The stream not being well sustained, however, the power sometimes falls very low, and for two months in the summer of 1882 not more than 20 horse-power could be realized for 24 hours in the day. The roll-way of the dam is 200 feet long and 18 or 20 feet high. It has stone abutments, and from the north end an embankment 250 or 300 feet long extends to the gate-opening, closely adjacent to which is the mill. The dam was at first entirely of wood, but in the flood of 1878 water worked around the south abutment and carried it away in part, though the roll-way stood almost entire. The water at that time rose so as just to trickle over the embankment, but the giving way of the abutment relieved the pressure and saved it. The force of the water pouring over the dam was tremendous, and tore up from the river-bed below great masses of rock, some containing from 100 to 150 cubic feet, and piled them up in a line across the stream 50 feet below the dam. The abutment and adjacent 25 feet of the roll-way were rebuilt, the latter of stone this time as well as the abutment. The main portion of the dam is of timber, with a sloping back supported in front by vertical and farther back by inclined braces. It is bolted down to a rock ledge and is very tight, showing no leakage of consequence.

A short distance up the river is the third privilege, utilized by the Pultze & Walkeley Company for the manufacture of manila paper. This company employs 11 feet fall and 70 horse-power of wheels. The dam is about 30 years old, and is a framed structure built upon a rock ledge of hard red sandstone.

Above this point there are said to be no important powers in use on Little river. Its upper course lies through a hilly wooded country, in which it has a moderate fall, a generally rocky bed, and firm gravelly banks. Except that it runs low at times, the stream is considered a good one for manufacturing purposes. Its water is soft and pure. It rises and falls rapidly, but might be rendered much more uniform and better sustained in droughts by the construction of reservoirs. These are perfectly practicable, and have been talked of somewhat, though there is no present prospect of their being built. It is reported that land for flowage is cheap in the upper waters, and that in the town of Blandford the stream drains three natural ponds which might be made useful for storage.

THE CHICOPEE RIVER.

The Chicopee river drains a large section in central Massachusetts, embracing portions of the four counties of Worcester, Franklin, Hampshire, and Hampden. It is the largest tributary of the Connecticut river in respect to drainage area, its basin containing 706 square miles. The main stream is formed at Three Rivers by the union, near that point, of the Quaboag, Ware, and Swift; it runs thence westerly through a distance of 15 miles, and joins the Connecticut river approximately midway between Springfield and Holyoke. This stream and its tributaries offer fine facilities for the use of water-power, which have already been largely availed of. The railroad communications are good, the Boston and Albany railroad and lines controlled by it reaching the greater part of the main river and its three principal affluents. The country drained is hilly, but the valleys are sufficiently open to accommodate large villages and important towns. The main Chicopee itself has gained great prominence by reason of the extensive cotton and other manufacturing interests carried on along its course. Its slope is considerable, averaging 15 or more feet per mile. The greater part of this fall has already been put to use, and in the autumn of 1882 but three undeveloped privileges were found along the whole course. One of these, at Southworth falls, was then being improved; another, the second privilege below Three Rivers, was about to be developed; and the third, immediately below Three Rivers, was owned and held for its own use by the Otis Company.

Elevations of points on the Chicopee river and tributaries (at railroad crossings).

Locality.	Elevation of water-surface above sea-level.	Fall between points.	Distance between points.	Fall per mile between points.
Quaboag and Chicopee rivers.	*Feet.*	*Feet.*	*Miles.*	*Feet.*
East Brookfield	600			
		4	8	0.5
West Brookfield	596			
		19	3	6.3
Warren	577			
		271	11	24.6
Palmer	306			
		268	18	14.9
Mouth of Chicopee, low water in Connecticut river	a 38–39			
Ware river.				
Cold Brook station	655			
		80	3	26.7
Barre Plains	575			
		28	8	3.5
Gilbertville	547			
Swift river.				
Enfield	393			
		52	10	5.2
Bondsville	341			

a See *Surveys and Explorations of the Connecticut River*, by Warren and Ellis.

NOTE.—These elevations were kindly furnished from the profiles of the Boston and Albany railroad by C. O. Russell, esq., general superintendent.

In his report upon the Connecticut river, General Ellis gives the least discharge from the Chicopee at 669 cubic feet per second. This corresponds to 0.95 cubic foot per second per square mile of drainage area, and, judging both by comparison with other streams and from the statements of manufacturers, seems too large. It is certain, however, that the dry-season flow of the river is very well sustained, though probably less so than it was twenty-five or fifty years ago. This valuable feature is, doubtless, largely contributed to by the numerous lakes and ponds which drain to the river through its tributaries, and is certainly assisted materially by the presence of extensive tracts of low marshy ground along the upper course of the Quaboag river. It was found impracticable to gain much reliable information regarding the reservoirs tributary to the Chicopee. Those used strictly for storage to meet the demands of the dry season seem to be few in number. The following list includes all the more important lakes and ponds in the very complete statement prepared by Mr. H. F. Walling for the Massachusetts State Board of Health.(*a*) It is probable that at the outlets of many of these small powers are in use, and that more or less control is exercised over their storage. At all events, they serve an important purpose, by reason of their number and large aggregate surface, in holding back the water of storms and melting snows, and yielding it gradually to the streams:

Principal lakes and ponds in the basin of the Chicopee river.

[From report by H. F. Walling.]

Locality (town).	Name of pond.	Area.	Tributary to what stream.
		Acres.	
Prescott	On West branch of Swift river	154	West branch of Swift river.
New Salem	Thompson's pond	235	Middle branch of Swift river.
Greenwich	Curtis pond	155	Do.
Do	Luce pond	124	Do.
Do	West pond	94	Do.
Petersham	Reservoir, name not given	175	Do.
Dana	Neeseponsett pond	118	Do.
Greenwich	Davis pond	100	East branch of Swift river.
Dana	Pottapaug pond	160	Do.
Phillipston	Phillipston pond	202	Burn Shirt river (to Ware).
Do	Pond northeast of above	130	Do.
Hubbardston	Reservoir near Westminster line	90	Ware river.
Do	Moosehorn pond	*a* 160	Do.
Do	Asnyconic pond	*a* 238	Do.
Hardwick	Muddy pond	202	Do.
Barre	Reservoir, name not given	200	Do.
Rutland	Pond west of center	135	Do.
Do	Long pond	160	Do.
Do	Demon pond	138	Do.
New Braintree	Two ponds near center	94 75	Quaboag river.
Oakham	Browning pond	140	Do.
West Brookfield	Wickaboag pond	*a* 323	Do.
North Brookfield	Brooks pond	178	Do.
Do	Furnace pond	305	Do.
Brookfield	Podunk pond	508	Do.
Do	South pond	340	Do.
Spencer	Cranberry Meadow pond	107	Do.
	Total area of 28 principal ponds	5,040	

a Said to be used for storage.

The bed of the Chicopee river is to a large extent gravel, with ledges of red sandstone crossing at intervals as at Chicopee Falls, Ludlow, and other points. The banks are of good height, rising occasionally at once to low hills, while again they are succeeded by level or gently-rolling meadow-land well cultivated. The surrounding country is comparatively level along the lower river, but becomes hilly toward Three Rivers. The first use of power in ascending the river is at Chicopee, but a short distance above the mouth. The river is there about 300 feet wide, and runs in rapids over low sandstone ledges. The main power is that of the Dwight Manufacturing Company, but intermediate between their dam and the foot of their property are two other dams, at which small powers are in use, depending, of course, for water upon the wastage from the upper privilege.

The lower dam is a log structure, varying from 3 to 6 feet in height and crossing the river in a very irregular line. The privilege is owned by Mr. E. Wood, and 12 feet fall and 40 horse-power are in use at the north end of the dam for a small grist-mill and a bobbin-shop. The supply of water is limited to waste at the upper dams and to the tail-water from the Ames factories, but is always sufficient for the power in use. This dam being the farthest one down stream, and a low one at that, considerable trouble is experienced from backwater from the Connecticut river, which at times sets up over the dam so as to hide it from sight and causes a stoppage of work for two weeks or more.

a See Appendix B to Report for 1873.

The next was formerly known as the Gaylord privilege, but is now owned by the Ames Sword Company. The dam is a fine structure of stone, having a natural rock abutment at the north end and an artificial one, of heavy masonry, at the south end, next the factory. About 100 men are employed in the works. The amount of power in use was not ascertained, but it is probably not large. The supply of water comes from the waste at the Dwight company's dam, and even when none is running over the latter the leakage through it during the 24 hours, stored in the small pond below, is sufficient to carry on the works, and so for five years it had not been necessary to run the engine a day.

The third privilege, including within its limits the two falls already mentioned, is owned chiefly by the Dwight Manufacturing Company, and in part also by the Ames Manufacturing Company; it takes up practically all the fall between Chicopee Falls and the Connecticut river. The dam is of cut stone part-way up from the base, with timber-work above, and is backed in with brick. The abutments and bulkhead are of masonry. The canal runs down the south bank to the mills, and, just below the dam it is provided with a waste-weir from 90 to 100 feet long; it has a total length of about 4,000 feet, and opposite the cotton-mills varies from 20 to 40 feet in width. Its capacity is said to be rather limited for the demands that are made upon it. First in order, descending the race, are the works of the Ames Manufacturing Company; 550 men are here employed in the manufacture of tools, sewing-machines, and bronze statuary. A fall of from 20 to 23 feet is obtained, and the company has a right to 130 cubic feet of water per second, only a portion of which is in use, however. Occupying the rest of the race are the great mills of the Dwight Manufacturing Company. They stretch along between the race and the river, and were formerly seven in number, but by connecting adjacent pairs have been consolidated into four. Both fine and coarse cotton goods are made, comprising sheetings, handkerchiefs, towelings, and other varieties. In September, 1882, there were being run about 112,000 spindles and 3,011 looms; 1,400 hands were employed, and 350 bales of cotton used per week. It was the intention soon to add 5,000 spindles and 240 looms to the works. Mill No. 7 discharges tail-water into the Connecticut river through a long race; the other mills discharge through short races directly into the Chicopee. The Dwight company employs a total wheel capacity of 2,268 horse-power, the heads in use ranging from 24 to 30 feet, according to position on the canal.

As regards priority in rights to water, the two manufacturing companies alternate, the Ames coming in first for a certain amount, then the Dwight, and then the Ames again. The supply of water is estimated to be sufficient to meet all demands that are made upon it for 8 or 9 months in the year. The pondage above the dam is small and of little assistance. A 400 and a 750 horse-power steam engine are in use for auxiliary power during low water and, if necessary, in high water. The smaller engine is first put into service; when that becomes insufficient it is stopped and the larger one started, and finally both may be put in operation. In the very dry summer of 1882 the large engine was started July 13, and for perhaps two or three days in a month during the season both engines together were unable to make up the deficiency in water-power.

The ordinary reduction of head due to spring freshets amounts to 6 or 8 feet, and is liable to remain at that figure for three or four weeks; in extreme cases the reduction has reached 15 or 20 feet. Anchor-ice runs in the canal and is a serious hinderance through the greater part of the winter, clogging on the racks and in the wheel-pits. Every winter morning when surface-ice of any amount is found on the canal it is broken up and floated out over a waste-way at the end of the race; the latter is thus kept open, and the danger of its packing full of cake-ice, as sometimes happens at Windsor Locks and other points, is avoided. Many men are required, however, in the work of removing the surface-ice and anchor-ice, and considerable expense is incurred.

The next privilege to be noticed is at Chicopee Falls, only a short distance farther up the river. Here, as at Chicopee, there is an intermediate dam opposite the main privilege. In this case it is owned by the Lamb Knitting Machine & Manufacturing Company, located on the south bank. This company obtains 9 feet fall, and for about eleven months in the year is enabled to run a 66 horse-power wheel, but during low water it relies upon steam. It has the benefit of any wastage at the upper dam and, except in low water, of the tail-water from two factories located on the upper privilege. Its dam is a log structure built some fifty years ago, measuring about 400 feet in length, and varying in height from $3\frac{1}{2}$ to 7 feet, according to the contour of the rock ledge on which it runs. At the north end of the dam Messrs. J. Stevens & Co., manufacturers of guns and pistols, use 6 feet head and 25 horse-power during the nine months, more or less, in which there is surplus water.

The Chicopee Manufacturing Company's dam is next in order. It is a timber structure, roll-way 306 feet long, with a vertical face, and is built 30 or 40 feet back from the edge of a sandstone ledge, over which there is an abrupt fall of several feet. The abutments are of masonry. The one at the south end is 10 feet wide and 20 feet long at the top, and contains two waste-gates, say 3 by 4 feet in size; it rises about 6 feet above the crest of the dam, and is prolonged inshore as a bulkhead 60 feet long and 8 feet wide, with 9 gate-openings, each about 5 feet square. The canal runs 2,000 feet down the south bank; through the Chicopee company's yard it is walled with granite masonry, and has a width of 50 feet and a depth of 10 feet, measured from the top of the walls.

At the north end of the dam the Belcher & Taylor Agricultural Tool Company uses $16\frac{1}{2}$ feet fall and 90 horse-power during the eleven months in an average year in which there is surplus water. On the south side of the river, a short distance below the bulkhead, B. & J. W. Belcher, manufacturers of agricultural tools, take water from the canal, using 10 or 12 feet fall and a 20 horse-power wheel. They have the first right to a small amount of water, but in practice shut down during low stages.

The great user of power at this privilege is the Chicopee Manufacturing Company, engaged in the production of canton flannels. In September, 1882, this company was employing 1,300 hands, running 62,000 spindles (22,000 of them day and night), 1,849 looms, and using 300 bales of cotton per week; the works were about to be extended, the number of looms was to be increased, and 30,000 spindles were to be added to the machinery then in use. There are four large mills, as follows:

No. 1, 438 by 95 feet, 4 stories high. No. 2, partially completed and in use, 220 by 95 feet, 4 stories high; length to be increased to 420 feet. No. 3, 150 by 50 feet, 5 stories high; with extension 140 by 38 feet, 3 stories high. No. 4, 234 by 50 feet, 5 stories high.

The head at the mills is 25 feet, and it is estimated that 1,100 effective horse-power is realized in the lowest stage of the river. The pond above the dam flows back 2 miles and is used in part as a reservoir; when full its surface is 3 feet above the water in the canal, and it can therefore be drawn down that amount without reducing the head along the latter. During the summer of 1882 it was regularly drawn down during the day about the depth mentioned, and at night did not fill sufficiently to cause a waste over the dam.

The ordinary freshet-rise on the dam does not exceed from 3 to 5 feet. In order to avoid trouble from ice the practice of the Chicopee company is to flush out its canal in winter whenever ice of any important thickness forms, and during a "cold snap" is done every morning. All the water is first drawn from the canal, allowing the ice to break and sink; water is then let in with a rush at the head-gates and carries the broken ice along with it and out through gates at the end of the canal. The magnitude of the pond and the absence of important rapids above are given as reasons why anchor-ice does not trouble here more than two or three mornings during the winter. It is also to be noted that as a rule the Chicopee company does not use nearly all the water, and frequently it is wasting over the dam at times when the Dwight company is receiving about the entire flow of the river into its race. Consequently, if anchor-ice is running in the stream, the latter company is likely to get much more of it than the former. The same is true of leaves in autumn, which are a serious hinderance to the Dwight company, but cause the Chicopee company very little inconvenience.

Just above slack-water from the Chicopee company's dam, there was being erected, in the summer of 1882, a new and fine dam of Monson granite. The site is about 2 miles above Chicopee Falls. The privilege is owned and was being developed by Messrs. J. H. Southworth & Sons, the power to be utilized in a large mill for the manufacture of fine writing papers. It was stated that there would be for rent four or five mill-powers, of 65 horse-power each, on the same side of the river with the Southworth mill. A supply of clear water, 1,000 gallons per minute, has been obtained at a distance of a third of a mile. It was estimated that the expense of grading for this privilege would be heavy, and it would be necessary to build a dike above the dam to prevent overflow, but the work was all being done in the most thorough manner. At the site of the dam the river-bed is composed mainly of ledge rock, but it was thought that some gravel might be met, and the design was for the corresponding portion of the dam to be modified by having the masonry rest directly upon a crib-work, about 3 feet deep, of squared timber, the interstices filled with broken stone. The design also provided for this portion an apron, extending, as a continuation of the crib-work already mentioned, some 10 or 11 feet down stream from the foot of the dam and supported at the end upon round piles; sheet-piling was also to be driven beneath the foot of the front and back slopes of the dam proper. The crest of the structure rises 15 or 16 feet above the river-bed, and has a length, transversely to the stream, of 250½ feet. The main portion of the dam is rubble-work, surmounted by an inclined coping between 6 and 7 feet wide of cut stone. The front slope of the dam has a batter of about 1 in 7, and the back slope of about 1 in 3. The masonry abutments rise 8 feet above the crest. The bulkhead is 50 feet long across the current, 16 feet wide, and is pierced by 7 gate-openings, each 5 feet wide. Wastage from the canal to the river is provided for by a weir 60 feet long immediately below the bulkhead.

Next in order is the fine privilege of the Indian Orchard Mills. The company manufactures sheetings, shirtings, and fancy cotton goods; runs 52,000 spindles and 1,168 looms, employs 675 hands, and uses 8,500 bales of cotton per year, turning out 250,000 yards of finished goods per week. It has two mills, 325 and 476 feet long, respectively. The improvements of this power are of the most substantial and workmanlike character. The dam rests on ledge rock, and has a face of cut stone, battering about 1 in 6 and backed by rubble-work. The crest is 28 feet above bed-rock, while the dam has a width at base of 30 feet and a roll-way 401 feet long. The top of the structure is covered with a course of sloping timbers, reaching out 4 or 5 feet from the stone-work and supported at the end by timber braces resting on a projecting course of stone in the face of the dam. The bulkhead has 9 gate-openings, each 3 by 4 or 4½ feet in size, besides a large one 20 by 12 feet. The canal is walled with masonry, and has a waste-weir to the river, immediately below the bulkhead, about 80 feet long.

In the heavy storm of October, 1869, there was a depth of only 4 feet on the dam, but this was considered a large rise. Above the dam there is a handsome pond of 80 or 90 acres, with a storage estimated to be sufficient for running the mills for five hours without any additions from the river. It is never drawn down more than about 33 inches below the crest of the dam, and fills up again at night, with a wastage before morning, through nearly the whole year. The fall along the canal ranges from 28 to 33 feet, and 1,034 horse-power of wheels is in use. Steam is not employed for power, but in a low stage of water the mills use about the full capacity of the river.

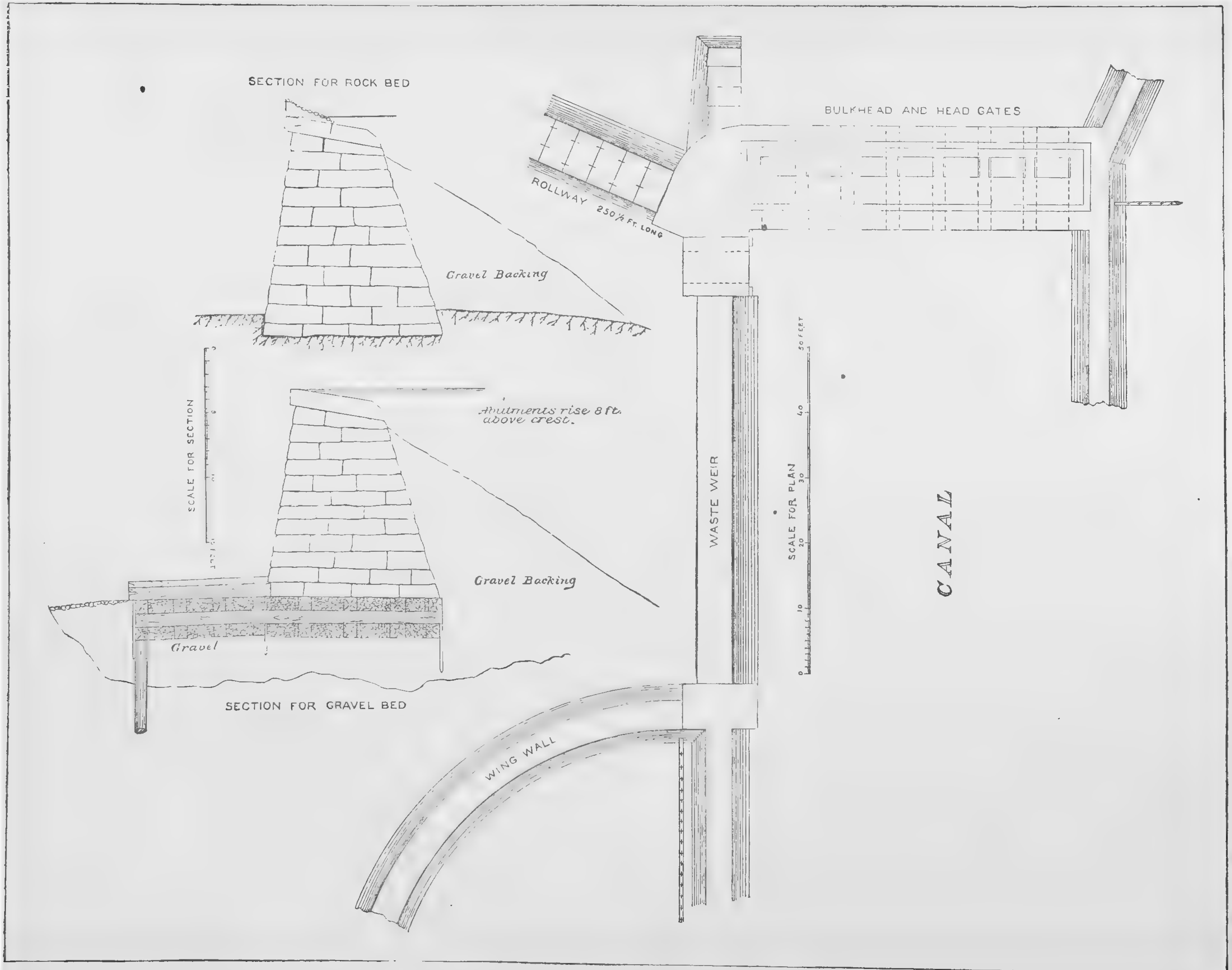

FIG. 20.—New Dam and Connecting Works at Southworth Falls.

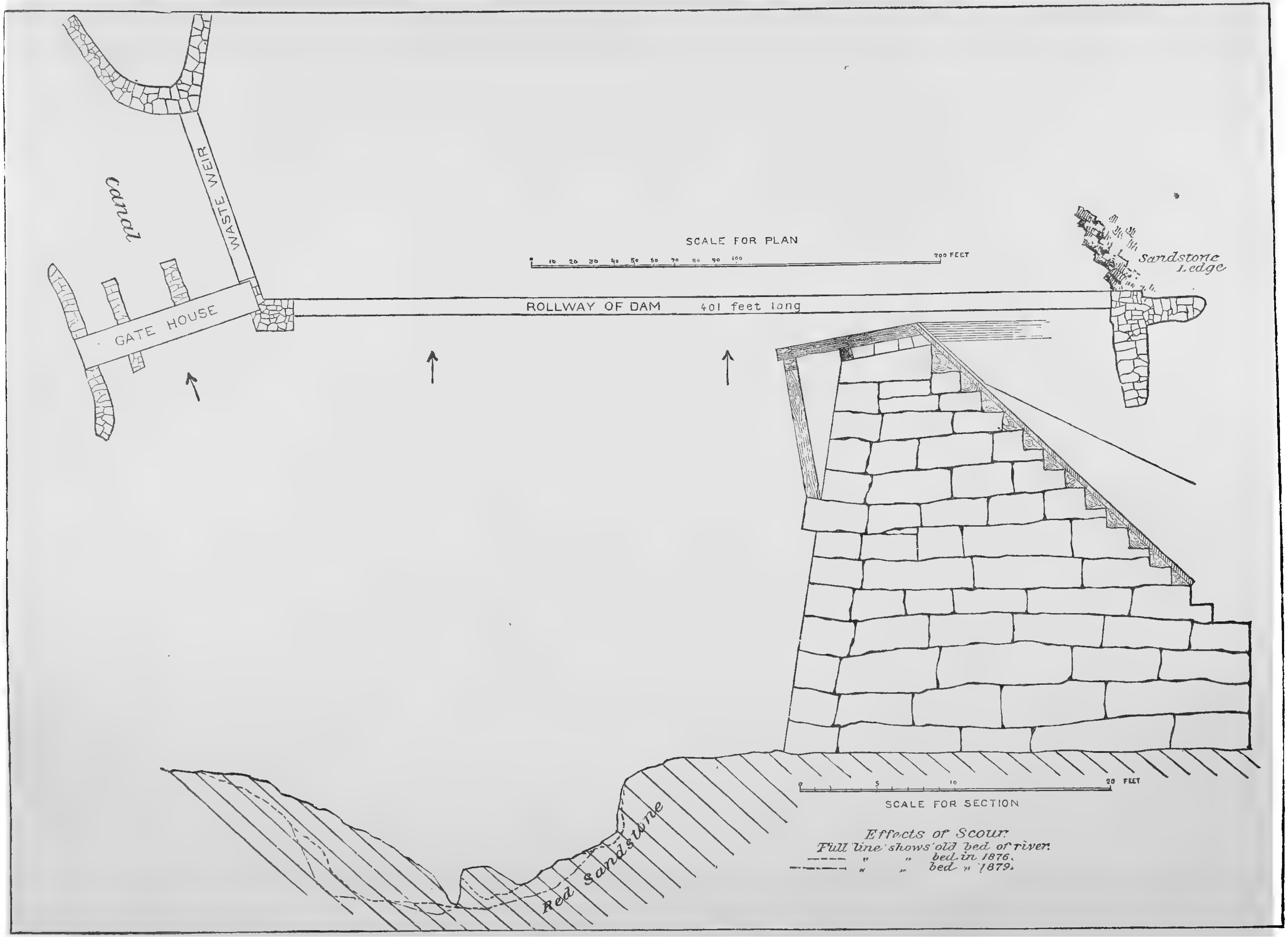

FIG. 21.—Cross-section of Dam at Indian Orchard.

Continuing above Indian Orchard, the river-banks are found to be generally of good height. The surrounding country is gently hilly, with some extensive level plains. The immediate valley has been quite thoroughly cleared of timber, but the distant hills are well wooded. Sandstone ledges continue to crop out in the river-bed.

Immediately above the Indian Orchard pond the Chicopee comes down through a rocky gorge and falls rapidly over ledges. It is there about 175 feet wide between banks, the latter 20 or 25 feet high. The Ludlow Manufacturing Company has here two water-privileges, with dams but a short distance apart. The lower dam is a log structure, resting upon and abutting against solid rock. It is about 140 feet long, 14 feet high, and is to be replaced by a new dam of the same construction. The manager of the company does not consider it safe to build a stone dam here, because of the seamy nature of the rock and its liability to be thrown out of position by frost. The great power both of frost and of water was strikingly exhibited at this point some years ago. The action of frost had separated from the solid bed of the river, just below the dam, a mass of rock measuring 24 feet in length, from 4 to 6 feet in width, and from 3 to 5 feet in depth. It lay pointing diagonally away from the dam; but when the Barre reservoir gave way, the great volume of water which came rushing down the stream turned the rock end for end, and left it supported upon one of the long edges and resting against the dam.

FIG. 22.—Falls at Ludlow.

The mills of the Ludlow company are on the north bank; three are located immediately below the dam, while a separate race, several hundred feet long, leads to No. 4. The manufacture comprises carpet-yarns (both jute and linen), crashes, twines, and gunny-bagging. The extreme fall on the privilege is 30 feet, and about 700 horse-power is in actual use. The company also holds for sale about 600 horse-power with ample building-room on the south bank. The available power of the privilege may be estimated follows:

Estimate of power at Ludlow.

Stage of river.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power. 1 foot fall.	30 feet fall.	Effective horse-power utilized
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year							300	34.08	1,020	
Low water, average year	11½	12	12	10	45½	672	390	44.30	1,330	700
Available 10 months, average year							450	51.12	1,530	

a In low stages a very material increase of the flow and power as here given can be realized for ten or twelve hours in the day by pondage above.

The upper dam is built of logs, runs upon and abuts against ledges of rock, and presents an angle up stream; it is about 200 feet long and 12 feet high. The fall on this privilege is 13 feet, and at the north end of the dam the Ludlow company had, at the time it was visited, from 60 to 75 horse-power employed in making window-frames and in preparing building materials. A new mill, 248 feet long by 60 and 76 feet wide, was soon to be built for the manufacture of twine. At the south end of the dam the company rents about 65 horse-power to a grist-mill having a capacity for grinding from 1,200 to 1,500 bushels of corn per day. Both the dams which have been mentioned were built fifty or more years ago. Above the upper dam there is a large storage, the pond setting back to the Collins Manufacturing Company's privilege.

The power just alluded to is about 11 miles, by water, from the mouth of the river. It is improved by a dam of rubble cement masonry, with abutments of the same construction, and a plank apron extending 30 feet down stream. The abutments rise 7½ feet above the crest of the dam. The bulkhead is from 55 to 60 feet long, 8 feet wide, and has 9 gate-openings. The canal runs perhaps 1,000 feet down the south bank, to the mill, with a width of about 45 feet, and just below the dam has a 50-foot waste-weir. The Collins Manufacturing Company employs 200 hands in the production of fine writing papers. A fall of 12 or 13 feet is obtained at the mill, and about 500 horse-power of wheels is in use day and night. Commonly there is a sufficient supply of water throughout the year, but for one month in the summer of 1882 it fell short and the mill could be run only 18 hours per day, water being scarce in the morning.

Between backwater of the privilege just described, and the Otis Company's utilized privilege at Three Rivers, there is stated to be a fall of about 40 feet, divided nearly equally into two powers. The lower of these was formerly

owned by the A. & W. Sprague Manufacturing Company, but has recently been sold, and has passed into the control of Mr. Edwin D. Metcalf, of Springfield. Mr. Metcalf states that his intention is to build a stone dam, and that he will probably so improve the power as to afford facilities for a cotton-mill and a paper-mill. By mutual agreement with the Otis Company the dam is to be so constructed as to give a fall of between 21 and 22 feet.

Estimate of power at Metcalf's privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	21 *feet fall.*
Low water, dry year	650	290	32.94	690
Low water, average year		380	43.17	910
Available 10 months, average year		440	49.98	1,050

The remaining 20 feet, or thereabout, of fall from Three Rivers is owned by the Otis Company and reserved for its own future needs.

The last power on the Chicopee river is at Three Rivers, and embraces 20 feet fall, although only 18 feet is actually in use. It receives the benefit of the water from each of the three tributaries, Quaboag, Ware, and Swift, which unite near this point to make up the main river. The dam is 175 feet long between abutments, and about 10 feet high; it is constructed of hewn timbers, has a vertical face, and rests upon a rock foundation. The abutments are of dry stone, faced with planking. Through a wooden bulkhead with 5 gate-openings, water is admitted to the race, which leads down the south bank to the Otis Company's mill. About 500 horse-power is there in use, and can always be realized during the day-time, even in the lowest stage of the river, without drawing down the pond so but that it will fill up again within two hours after the gates are shut. The main mill is 290 by 75 feet in size, 4 stories high, with an L of 204 by 50 feet. The principal productions are seersuckers, fancy denims, and apron checks and stripes; 22,500 spindles and 700 looms are run here and 700 hands employed. The company has still more important mills above, at Ware.

Summary of water-privileges on the Chicopee river.

Locality.	Distances from mouth.	Company.	Manufacture.	Extreme fall on privilege.	Remarks.
	Miles.			*Feet.*	
Three Rivers	15½	Otis Company	Seersuckers, fancy denims, and apron checks and stripes.	20	18 feet fall and about 500 horse-power in use; 700 looms, 22,500 spindles.
Between Three Rivers and Collins station.	13–14	Owned by Otis Company	Unimproved	20±	Held for company's use.
Do	11–12	Held by E. D. Metcalf, of Springfield.	....do	21.3	To be improved.
Collins station	10–11	Collins Manufacturing Company.	Fine writing papers	13	513 horse-power in use.
Ludlow	7½	Owned by Ludlow Manufacturing Company.	Power used by grist-mill and wood-working shop.	13	About 125 horse-power in use. Ludlow company will erect a large twine-mill.
Do		Ludlow Manufacturing Company.	Carpet-yarns, crashes, twines, and gunny-bagging.	30	About 700 horse-power in use. Company holds for sale 600 horse-power and land on south side of river.
Indian Orchard	6½	Indian Orchard Mills	Sheetings, shirtings, and fancy cotton goods.	33	1,168 looms, 52,000 spindles; 1,034 horse-power in use.
Southworth falls	4–5	J. H. Southworth & Sons	To be used in paper-manufacture.	16–18	Privilege was being developed in fall of 1882. There were to be for rent 4 or 5 mill-powers, of 65 horse-power each.
Chicopee Falls	2	Chicopee Manufacturing Company.	Canton flannels	25–28	Company owns privilege and obtains 1,100 horse-power in lowest stage of river; 1,849 looms, 62,000 spindles (spindles and looms to be increased).
Do		Belcher & Taylor Agricultural Tool Company.	Agricultural tools		On main privilege. Has 16½ feet fall and 90 horse-power 11 months in the year.
Do		B. & J. W. Belcher	....do		On main canal. Use 20 horse-power most of the year.
Do		Lamb Knitting Machine & Manufacturing Company.			Uses 9 feet fall and 66 horse-power at intermediate dam.
Do		J. Stevens & Co	Guns and pistols		Use 25 horse-power part of the year from the Lamb company's dam.
Chicopee	¾	Dwight Manufacturing Company.	Sheetings, handkerchiefs, towelings, and other goods.	30	Principal owner of privilege, and uses 2,268 horse-power.
Do		Ames Manufacturing Company.	Tools, sewing-machines, and bronze statuary.		On main canal. Entitled to 130 cubic feet of water per second.
Do		Ames Sword Company	Swords		At intermediate dam.
Do		Privilege owned by E. Wood	Grist-mill, and power rented to bobbin-shop.		At a second intermediate dam.

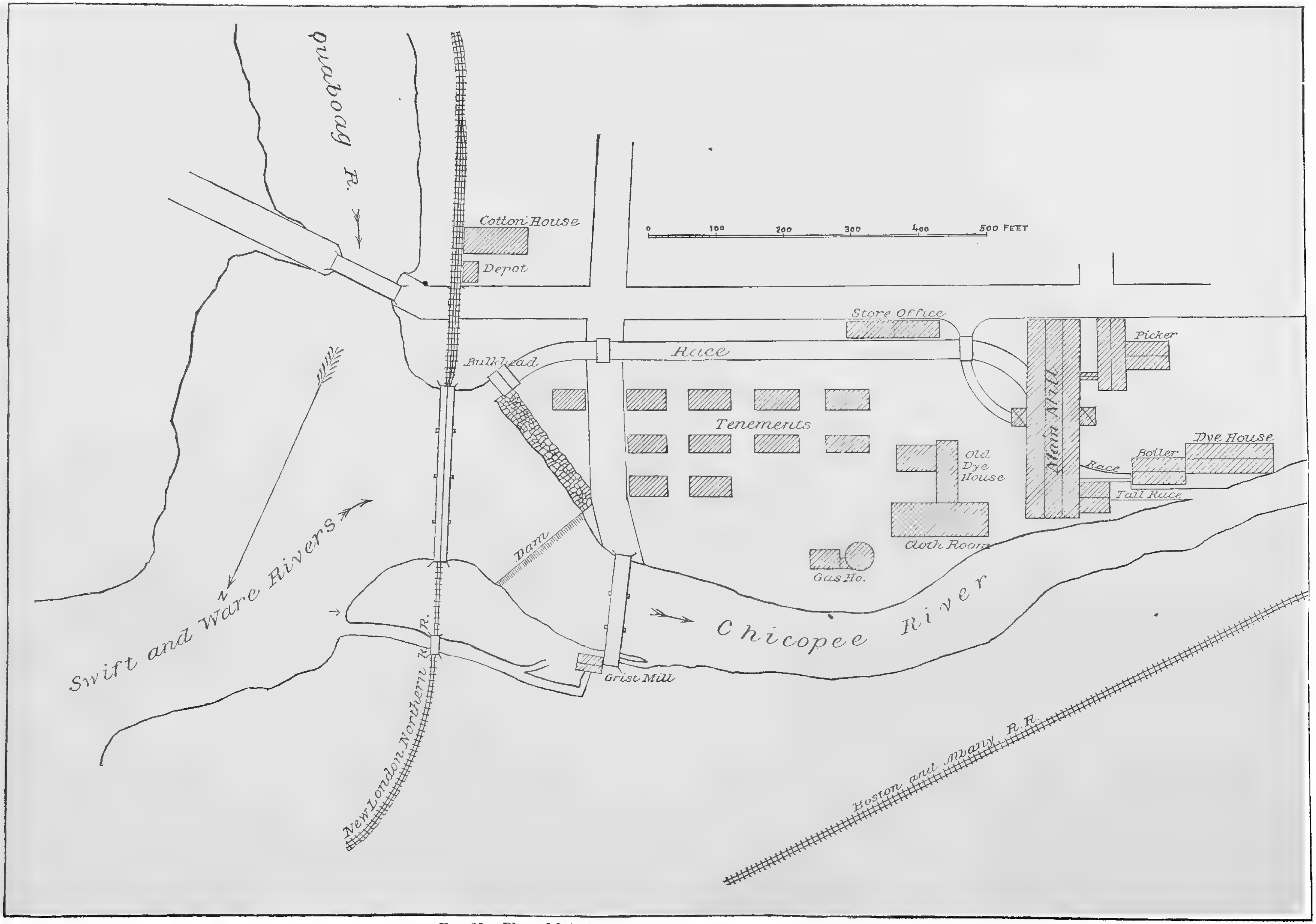

Fig. 23.—Plan of Otis Company's Water-Privilege at Three Rivers.

TRIBUTARIES OF THE CHICOPEE RIVER.

The Quaboag river.—The Quaboag is the most southerly of the three principal streams which unite to form the Chicopee. Two or three small streams come together near East Brookfield, in the southwestern part of Worcester county, and make up the main Quaboag, which then takes a westerly course, through about 25 miles, to Three Rivers. For the greater part of this distance the Boston and Albany railroad follows the river closely. The drainage area comprises 210 square miles. From East Brookfield to Three Rivers there is a fall of 300 feet, of which only 100 feet is in use; in other words, two-thirds the fall of the stream, and that toward the mouth, where the volume is greatest, is not utilized.

The stream is especially valuable for power on account of its well-sustained flow. There is an absence also of disastrous freshets. On Knowles and Gould's dam, at Warren, about 100 feet long, the largest freshet-rise is only 2 or 3 feet; and on the West Warren dams, about 110 feet long, the depth in a common spring freshet does not exceed 18 inches. At East Brookfield there is said to be a large poundage above the dam, but the only strictly storage reservoir learned of as supplying the stream is in West Brookfield. It is known as the Brookfield reservoir, is the property of the West Warren Cotton Mills; it fills regularly, flows 350 acres,(*a*) and can be drawn down 6 feet from a full stage. But though there are not many artificial reservoirs, the stream derives great assistance from the natural reservoir afforded by the extensive meadows, said to contain thousands of acres, which border its course most of the way between Warren and East Brookfield. The fall of the stream in this distance is very small, amounting to but 4 feet in 8 or 9 miles. The meadows are almost on a level with the stream, and though commonly dry are overflowed in high water. The bogs and grass which cover them retard the draining off of water and contribute greatly to the uniformity of the stream. They yield an inferior quality of grass, but it is thought that the expense of flooding them permanently by a dam would be rendered unbearable by reason of the damages for flowage.

Backwater from the Otis Company's dam at Three Rivers stops considerably short of Palmer, but thence up to Blanchardville, 2½ miles by river above Palmer, the fall is reported too small to be of importance.

The first privilege to be noticed is owned by Mr. Franklin Blanchard. An irregular ridge of stones across the river forms a dam a couple of feet high. The river makes a bend below, across the neck of which a race leads. This formerly carried water to a factory where Blanchard Brothers made plow-handles, but the factory burned. The river is about 100 feet wide at the dam. The privilege is a fair one, but the canal is on the opposite side of the river from the railroad, and the available fall, as the power was formerly used, is only 6 or 7 feet. A portion of this fall, however, might be incorporated to good advantage into the privilege immediately above.

This second privilege was in use some years ago by a large grist-mill and by scythe-works, and they also burned. The framed dam still remains in fair condition; it has dry-stone abutments, between which it is 144 feet long. On the south side power is rented to J. H. Smith for a small shoddy-mill, and on the north side is the old race leading to ruins of the scythe-works. Messrs. A. V. Blanchard & Co. own this privilege and hold it for sale. The fall is 10 feet at the dam, which can be raised 4 feet, overflowing thus a moderate amount of rather poor land. The pond is at present long and narrow, setting back 200 or 300 rods. The power is a good one and well located; the railroad is close at hand, and crosses the highway only a few hundred feet from the dam. On the same side, a short distance below, is an admirable site for a mill and a village.

Above Blanchardville the river continues shoal and descends rapidly over a gravelly bed. The surrounding country rises to quite high hills, fairly wooded with a young growth. In places the hills are steep and rocky, but in general their slopes are moderate. Up to the vicinity of West Brimfield the immediate course of the stream is flanked by low meadows. Beginning at a point about 3½ miles by road from Palmer, Joseph King, who resides near by, owns the land on the north side for a mile up stream, and claims a privilege with a fall of 15 or 20 feet available.

At West Brimfield the valley is open, there is a railroad station and a small village, and the site is an excellent one for the use of power. A. W. Crossman & Son, of West Warren, own 20 feet of fall here.

A short distance above the West Brimfield station the hills close in and the valley becomes contracted. It continues substantially the same up to West Warren, and though in the intervening distance there is a large unimproved fall, owned and held for sale by the George H. Gilbert Manufacturing Company, of Ware, the facilities for building large mills and the accompanying villages are not favorable.

A little way below West Warren power was formerly used to run a forge, and portions of a framed dam are still left. The river here narrows to 50 feet or less, and has a rapid descent; the valley is narrow below the dam, and does not offer a very good building-site. The privilege is claimed to have an available fall of 18 feet, and is owned by A. W. Crossman & Son.

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a This is probably the same body of water mentioned by Walling as Wickaboag pond, containing 323(?) acres (see list of lakes and ponds previously given).

From West Warren to Palmer there is an unimproved fall of, in round numbers, 200 feet. It is not to be supposed that all of this would or could be utilized to good advantage in practice, and the proportion really available can be determined only by a more thorough examination than was made; but some idea of the gross power corresponding to the fall at the various points mentioned, and for the whole distance, may perhaps be obtained from the following estimate:

Estimate of unimproved power on the Quaboag river between West Warren and Palmer.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours (*a*)	Theoretical horse-power.						
			Blanchardville.		King's privilege, say 15 feet fall.	West Brimfield, say 20 feet fall.	Old forge, say 18 feet fall.	1 foot fall (mean).	200 feet fall.
			7 feet fall.	14 feet fall.					
	Sq. miles.	*Cubic feet.*							
Low water, dry year	*b*142, *c*179	60–70	55	110	110	150	120	7.38	1,480
Low water, average year		80–100	80	160	150	200	160	10.22	2,040
Available 10 months, average year		90–120	95	190	180	240	180	11.93	2,390

a A considerable increase of the flow and power as here given could probably be realized for ten or twelve hours in the day, by reason of the control exercised over the stream above.

b At West Warren.

c At Blanchardville.

NOTE.—Rainfall on drainage area, 11½ inches in spring, 12 in summer, 12 in autumn, 10 in winter, and 45½ for the year.

The lower privilege at West Warren is occupied by A. W. Crossman & Son, manufacturers of edge-tools. They have a fall of 12 feet, and two 40 horse-power water-wheels, but do not use their full capacity.

The principal users of power here are the West Warren Cotton Mills, running 770 looms and 32,000 spindles in the manufacture of denims, tickings, and dress-goods; 650 hands are employed, and 30 bales of cotton consumed per week, with a production of 150,000 yards of goods in the same time. The company has four mills—one just completed and not in use when visited—occupying successive privileges and scattered perhaps half a mile along the river. The valley widens out at this point, yet the ground is rather hilly along the stream, and the expense of grading for the mills and other works is said to have been large. The improvements are of the most substantial character. The mills are of brick and the dams of stone in cement. The races are short and do not exceed 300 or 400 feet in length, except at mill No. 2, which has a race 1,450 feet long. The pondage above the dams is small, estimated at possibly 25 or 30 acres in all for the four privileges.

Ascending the stream the powers occur in the following order:

Mill No. 3, 200 by 60 feet, 4 stories high; dam 109 feet long, fall 16 feet.

Mill No. 1, 300 by 75 feet, 2 stories high; dam 111 feet long, fall 16 feet.

Mill No. 2, 180 by 51 feet, 4 stories high; dam 110 feet long, fall 15 feet.

Mill No. 4, 170 by 51 feet, 4 stories high; dam 130 or 140 feet long, fall 12 feet.

At the three lower mills a total of 650 horse-power is in use, and can be obtained nine or ten months in an average year; for the remaining time about three-quarters of that amount is realized.

This company also owns, and holds for its own use, 8 or 9 feet of unimproved fall between the No. 4 mill and the privilege at Warren.

At Warren, Messrs. Sayles, Owen, & Co., manufacturers of fancy cassimeres, use 11½ feet fall and 125 horse-power; they run 9 sets of cards. The river-bed is here composed of gravel and bowlders. The dam is mainly of dry stone, but is surmounted by a log addition. The pondage is small, and allows water to waste past the mill even in seasons when it is needed.

The next privilege, also at Warren, is owned jointly by Messrs. Knowles and Gould. L. J. Knowles runs 1,300 spindles in the manufacture of cotton-warp, obtaining 5½ feet fall and using one 35 horse-power wheel. John B. Gould takes power for a 3-run grist-mill, and a blacksmith shop also uses a little power at times. Above the backwater from Knowles and Gould's dam there begins the long flat reach of river previously described, and the stream was not examined farther.

Chicopee brook is a small stream running northerly through the town of Monson, and joining the Quaboag a little east of Palmer. It drains 23 square miles. Near Monson village a fine quality of granite is quarried in large quantities. The country in this section is hilly but open, and the soil is largely composed of a sandy loam. Springs are abundant, and the stream is as well sustained as could be expected considering that it is without storage reservoirs. Opinions vary among the mill-owners as to whether these could be constructed to good advantage. It is said that there is swampy land in the upper waters which could be flowed. But whether that is true or not, some of the manufacturers are averse to reservoirs, because of their alleged expense and the danger from their failure. In its present condition, however, the stream certainly runs very low at times. It is overloaded with

machinery, and nearly all the mills use steam in part for power. The fall is about all taken up in the main portion of the stream. The mills are of moderate size, and in nearly every case manufacture fancy cassimeres.

Principal water-privileges on Chicopee brook.

Locality.	Firm.	Manufacture.	Fall.	Horse power of wheels.	Remarks.
			Feet.		
South Monson	C. W. Holmes, jr	Plain cassimeres	22	20	2 sets of cards. Uses steam all the time, in part.
Do	D. W. Ellis & Son	Fancy cassimeres	23	......	4 sets of cards. Use steam in low water. Pond night-water in the dry season.
Do	J. L. Reynolds	...do	15	40	3 sets of cards. Uses steam in part for power.
Do	R. M. & Theo. Reynolds	...do	17	50	3 sets of cards. Use steam in part for power. Store night-water 6 months in the year.
Monson	S. F. Cushman	...do	10	30	4 sets of cards. Uses steam in part for power.
North Monson	H. C. Day	Grist-mill	9	20	2 runs of stone.
Do	John F. Heery & Brother	Fancy cassimeres	12	50	7 sets of cards. Can get 50 horse-power by water 8 months in the year, but use steam more or less at all times.

The Ware river.—The main stream may be regarded as formed in the town of Barre, Worcester county, although the Burn Shirt river and Canesto brook, which go to make it up, have their sources to the northward, in Phillipston and Templeton. The drainage area is 214 square miles. From the junction of the Burn Shirt and Canesto to Three Rivers the Ware is 28 miles long. The surrounding country is hilly, but in the lower course, at least, the immediate valley is in general open, accessible, and very well suited to the establishment of villages. The timber has been largely cleared away and the land given up to pasturage. The stream is well sustained in the dry season, but more rapid in rise and fall than the Quaboag, and, so far as could be ascertained, is destitute of the extensive marshes which characterize a portion of that river. Moosehorn and Asnyconic ponds, lying in the town of Hubbardston, and together containing about 400 acres, are used for storage to meet the demands of the summer season, and there may be one or two other ponds in the upper waters serving a similar purpose. The two above mentioned are owned by the Otis Company, and prove sufficient, in a dry season, to maintain the necessary volume at Ware for from four to six weeks. The reservoir capacity of the stream can be largely increased, and a plan looking to that end has already been developed. At Barre falls, by a dam 25 feet high and from 300 to 400 feet long, a flowage of 1,178 acres can be obtained, with a storage of about 490,000,000 cubic feet; and it is estimated that the reservoir could be filled three times in each year. Some $12,000 has already been expended in buying land and engineering and other work, and it is estimated that as much as $70,000 would be required to complete the enterprise. Toward the actual construction of the reservoir no work has yet been done, on account of a disagreement among the mill-owners as to bearing the expense. Nearly all the companies along the river are interested in the project, which is still under consideration.

A number of years ago a small pond of about 70 acres, known as the Barre reservoir, gave way and caused a large amount of damage. The accident occurred on the night of September 30–October 1, 1869. The cause is supposed to have been that the waste-way had become choked with brush and floating drift, and that during a very heavy rain and strong northwest wind on that night the waves were forced with considerable power against the top of the gravel dam, and, gullying out little by little, soon produced a large channel, which the violent rains helped to wash down, and the failure of the whole structure then naturally followed. The loss by this disaster is estimated to have been $200,000.

The first power on this stream above the mouth is at Thorndike, where the Thorndike Company has two falls and large mills for the manufacture of colored cotton goods—tickings, denims, and stripes; 110 bales of cotton are used per week, the company running 33,000 spindles and 700 looms, and employing about 500 hands. The lower dam is built of stone in cement, and has a vertical face. The roll-way is 150 feet long, with an average height of 12 feet; it is 20 feet wide at the base, and narrows but little till near the top, which is covered with 8-foot coping-stones. The main portion of the dam was built about 1872, but, the freshet-rise above it having been found too great, the length was increased 60 feet two years later. The race is merely an excavation in earth, without walls, and measures about 500 feet in length, 25 in width, and 10 in depth at the center. The head at the main mill is 19 feet, and in the addition to the mill 15 feet, 310 horse-power being used altogether.

The upper dam of the Thorndike Company is a framed structure with stone abutments. The roll-way is 175 feet long, 14 feet high, and 26 feet wide at the base; the front row of braces is vertical, the rows farther back being somewhat inclined. This dam was built about the year 1876, and cost in round numbers $7,000. Water is carried from the dam in a race across a bend of the river to the mill, where about 300 horse-power is used under 20 feet fall.

The power used at these mills will give a fair idea of the minimum capacity of the stream, since during the very dry summer of 1882 there was a lack of water for running at full capacity only two days, and then the shortage was slight. The pond above the lower dam is small and of no consequence, but the upper pond sets back for 2

miles, and stores an important amount of water. From morning until about 2 o'clock, at which time the water used at Ware reaches this point, this pond has to supply the mills during low stages of the river, and is thus liable to be drawn down about 3 feet. The night-flow of the stream is ponded here for about two months in a very dry season, but in some years there is, throughout, a waste over the dam at night. The ordinary spring-freshet rise on the dams is in the neighborhood of 3 feet. The large upper pond holds back ice through the winter, and long enough so that it usually becomes well rotted before going out. Occasionally gorges form in the river below Thorndike, and cause backwater there temporarily; in extreme cases the river has even been set back into the mill and a stoppage of work forced.

From Thorndike to Ware, a distance of 7 miles, the valley is open and the stream bordered by narrow meadows. The statement was made, on not very good authority, that at some point below Ware a privilege with 15 feet fall is claimed, but this section of the river is generally described as flat and presenting little opportunity for the use of power.

At Ware the character of the stream changes for a time, and within the limits of the village it descends about 70 feet over rock ledges. The lowest privilege is occupied by the George H. Gilbert Manufacturing Company, which has also two large mills above at Gilbertville. The dam here is a low framed structure, running diagonally across the river, and giving a fall of 7 feet at the mill. The manufacture at the latter comprises fine flannels, soft woolens, and blankets, and 7 sets of cards are run.

Above this privilege the Otis Company has two dams, three falls, and three large mills. The upper dam runs across a rocky gorge, and has an extreme height of 30 feet. The roll-way is 117 feet long, 30 feet wide at the base and 6 feet at the top; the face is nearly or quite vertical. The dam is built of granite in cement, and on either side is dovetailed into the solid rock. A race 1,000 feet, more or less, in length conveys water from the bulkhead to the upper mill, where 400 (*a*) or more horse-power is in use, under 28 feet fall. The tail-water from the upper mill is carried by a short race to the second mill and is then discharged into the river. At this mill a fall of 19.3 feet and something over 200 horse-power are in use. The water thus far used, having been returned to the river, is held by the second dam, and on the north side furnishes 121 horse-power, under 16.3 feet fall, to the Otis Company's lower mill, and on the south side of the river is utilized by Messrs. C. A. Stevens & Co., manufacturers of flannels and dress-goods. As already stated, the Otis Company has large works at Three Rivers. At Ware it manufactures mainly denims, ticks, and checks, but also runs an important portion of its works on hosiery. In the mills here are operated 32,750 spindles and 662 looms, and employment is given to 1,450 hands.

The supply of water is commonly sufficient for running the mills at full capacity throughout the year, and during the trying summer of 1882 there was a slight shortage for only eight days. All the improvements at Ware are of the most substantial nature, and especially so on the premises of the Otis Company. The mills are of stone or brick, and on the company's grounds the races are walled with granite masonry.

Between Ware and Gilbertville, 4 miles, the river is bordered by flat meadows, and the fall is said to be too small to admit of a water-privilege.

At Gilbertville all the fall is owned by the George H. Gilbert Manufacturing Company. The same kinds of goods are made as at its mill in Ware; 31 sets of cards are run and 550 hands employed. The lower privilege, as at present improved, embraces 14 feet fall, which can be increased 6 or 8 feet by extending a moderate distance down stream. This privilege is not for sale, but power is rented to N. G. Reed for a box-shop and a small grist-mill. The two succeeding falls above, of 18 feet and 20 or 22 feet, respectively, are used by the Gilbert company, furnishing to two mills an aggregate of about 600 horse-power. The river-bed in this vicinity is mainly composed of gravel and bowlders. The immediate valley is rather narrow, and the village is very prettily located on rising ground. The pondage above the lower dams is small, but the upper dam sets the river back a long way and affords a good storage. Still farther up the stream is said to continue quite flat on to the Hardwick paper-mill privilege, but no examination was made above Gilbertville, 14 miles from the mouth.

The Swift river.—The Middle branch of the Swift river has its source in North pond, in the town of Orange; running southerly, it is joined, a mile or two above Enfield, by the East branch, and again, a couple of miles below the village, by the West branch. The distance, by river, from North pond to Three Rivers is 30 miles. The total area drained is 209 square miles. The stream is considered to be quite uniform, well sustained in summer, and well suited to manufacturing. So far as could learned there are no storage reservoirs for use during the dry season, although it is said that they could be built without much difficulty; but there are a number of natural ponds in the basin, and above Enfield the Middle branch frequently spreads out, and so forms a chain of several ponds along its course. The country drained, by the Middle branch at least, is hilly, and tolerably well wooded with a young growth of timber.

The first water-privilege above Three Rivers, on Swift river, is at Barrett's Junction, about 2 miles from the mouth, and is owned by the Barrett's Junction Water Power Company. The dam is about 120 feet long between abutments, 10 feet high, and was built in 1881 at an approximate cost of $5,000. It rests on rock, and is built up as a log crib-work sloping each way from the top. It sets the river back for about half a mile, giving a very good

a The falls at the two upper levels have recently been changed somewhat, but with the old fall of 25 or 26 feet at the first level, the wheels were rated at a total of 389 horse-power.

storage. A long canal runs from the vicinity of the dam, cutting somewhat across a bend of the stream and leaving room in between for mills. Near the lower end of this race a small side canal carries water to a wheel from which, by wire cable, power is transmitted several hundred feet across the river to the works of the Springfield Soapstone Company, which rents 125 horse-power.

The fall on this privilege is 20 feet, and the available power is estimated by the water-power company at 500 horse-power in a low stage of the river. The company owns 65 acres of land in the bend of the river, said to be level and well suited for sites for mills and a village. The dam, canal, and land have cost about $20,000. The company wishes to sell its land and lease the power; the rental charged the Springfield company, and which would probably be the same for other concerns, is about $9 per horse-power. A short distance below the dam Jabish brook, quite an important little stream, empties into the river. The design is to build another dam below the mouth of this brook, and then to use its water and the waste from the upper dam to run the soapstone works, leaving the whole power from the main canal still for rental. The New London Northern railroad proposes to cross the river on a bridge for which the abutments of the new dam shall serve as supports, and to run conveniently through the company's property. The power available here may be estimated as follows:

Estimate of power at Barrett's Junction.

Stage of river.	Rainfall on basin.					Drainage area. (a)	Flow per second, average for the 24 hours. (b)	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	
Low water, dry year							90	10.22	200	
Low water, average year	11½	12	12	10	45½	207	120	13.63	270	125
Available 10 months, average year							140	15.90	320	

a Including that of Jabish brook. *b* In low water the flow and power can be doubled for 12 hours.

At Bondsville, a little way farther up stream, the Boston Duck Company owns two falls, both improved. At the time this place was visited the lower dam and canal had been built, and the company designed to erect soon a mill in connection for the manufacture of some kind of cotton goods. The available fall on this privilege is 21.2 feet, and leaves nothing of importance down to Barrett's Junction, a half-mile below.

The two dams at Bondsville are in style of construction almost exactly alike, varying slightly in dimensions. The lower was built in 1879, and cost $14,000. It is of stone in cement, cut bed and build, and is of uniform construction from face to back, with roll-way 145 feet long. The base is 16 feet, the height 12 feet from top of apron-stone to top of coping, and the face has a batter of an inch and a half to the foot. The coping-stones project 12 inches from the face of the dam, are 12 inches thick, 9 feet long, and slope back at the rate of perhaps 1 in 4. The face of the dam rests directly on apron-stones, which project 2 feet under it and 11 feet in front. The back of the dam rests upon a priming-wall 2 feet thick and 6 feet deep, and the down-stream end of the apron rests upon a similar wall 4 feet deep. The space between these two walls is filled in with grouted gravel. The natural bed of the stream here is entirely gravel.

The upper dam is 15 feet high, 18 feet wide at the base, with roll-way 130 feet long, and cost $20,000. A canal about 1,000 feet long leads to the mill, where about 500 horse-power is used under 21 feet fall. The Boston Duck Company manufactures light cotton-duck, runs 18,000 spindles and 324 looms, and employs 400 hands. A 160 horse-power engine is used for auxiliary power in low water, and during the summer of 1882 was run for 30 days. The upper dam sets the river back some 3 miles and gives a large storage, so that in a very dry season the night-flow of the stream is ponded for a period of two or three weeks.

Above Bondsville there is said to be no opportunity for a privilege before reaching West Ware. At that point there is a log dam, from 150 to 200 feet long, with a fall of 8 feet. Three-quarters of this privilege is said to be owned by J. B. Warren, of Springfield, and one-quarter by the proprietor of a small cotton-batting mill on the right bank. It is claimed that by extending the present canal 200 rods, or, much better, by building a new dam that distance down stream, a fall of 16 feet can be realized, and a good flowage.

Estimate of power at West Ware.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power.			Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	*16 feet fall.*	
Low water, dry year		70	7.95	65	130	
Low water, average year	183	100	11.36	90	180	35
Available 10 months, average year		120	13.63	110	220	

a In low stages the flow and power can be doubled, during the ordinary working-hours, by pondage here and above.

The next dam is at Enfield, on the Middle branch, some 12 miles from Three Rivers. At the lower village the Minot Company uses 11 feet fall and 72 horse-power in the manufacture of woolen goods.

At the upper village the Swift River Company runs 8 sets of cards on fancy cassimeres. This company has 16 feet fall, and uses one wheel of 70 or 80 horse-power for the main mill, besides from 30 to 35 horse-power for a small saw-mill, grist-mill, and box-shop. There is a moderate pondage here, but a mile up stream the company has a low dam, consisting of a sill about even with the natural water-surface, surmounted by 15 or 18 inches of flash-boards; and as the river is very flat above, it is set back a long distance on both the Middle and East branches. The pond thus formed is used for storing the night-flow, which it does, without allowing wastage over the dam, for from three to six weeks in an average year.

The stream above Enfield was not visited. There are said to be occasional small mills in that portion, but none of special importance.

MILL RIVER.

This important little stream joins the Connecticut river from the west in the town of Northampton, Massachusetts. It is 16 miles long, and contains within its drainage basin 58 square miles. The section thus included is hilly, and toward the headwaters becomes quite elevated, with many steep and rocky slopes.

The stream is sustained in low water by two reservoirs, distant about 9 miles from the village of Leeds. They lie near the center of the town of Goshen, and about half a mile apart on the course of a small stream. The upper reservoir is the smaller, flows 64 acres, and can be drawn down about 15 feet from full-water line, though the average depth is much less. It lies close to the limits of the water-shed, and has, in fact, a dam at each end, the farther one to prevent flow over toward Cummington. It is fed partly by springs and one or two little brooks, but mainly by spring rains and melting snows, and fills readily. The lower reservoir flows 133 acres, and can be drawn down 25 feet at the gates. It receives no stream except the one coming from the upper reservoir, but fills regularly.

These reservoirs were built before the one which failed in 1874. They are owned by the Hampshire Reservoir Company, an association made up of ten or eleven of the mill-owners, who hold stock about in the proportion of their fall. Once in two years or so they are assessed for repairs. The reservoirs are usually drawn upon from the latter part of June till the middle of September, and the flow of the stream is kept up as nearly as possible to the wants of all but two or three of the largest mills. But even with the help of the reservoirs the supply of water is insufficient, and nearly all the mills have auxiliary steam-power. The present reservoirs could not be raised farther, but the Williamsburg reservoir, which failed, might be rebuilt, and would in that case be of great assistance to the stream. Its location was naturally fine, and many of the mill-owners are in favor of rebuilding it.

The breaking away of this reservoir, May 16, 1874, was a memorable disaster, and it may be well to give a few facts regarding the construction of the dam and the causes of its failure. Soon after the occurrence an examination was made by a committee of the American Society of Civil Engineers, and from their report (*a*) the information here given is almost entirely drawn. They described the dam as having been—

> * * * between 500 and 600 feet long, and about 43 feet high at the highest point near the center, diminishing to nothing at the ends, forming a reservoir when filled, in the valley above it, of an area of 111 acres, with an average depth of about 20 feet. At the time of the failure, the water was about 4 feet below the top of the embankment (not an unusual height at this season), and within a few months it has been at least a foot higher. The failure took place between 7 and 8 o'clock on the morning of May 16, last, when probably three-quarters of the contents of the reservoir escaped in about 20 minutes, or at the rate of about 60,000 cubic feet a second, destroying in its course through the steep and narrow valley below, 143 lives, and property to the amount of more than $1,000,000. The dam consists of an earthen embankment with a longitudinal wall of stone and cement through its center, a waste-way 33 feet wide in the natural ground at one end of the embankment, and a 16-inch pipe through the embankment and wall at the lowest point, for the discharge of the water as wanted for use at the mills below.

The dam was built in 1865 by the reservoir company, and therefore stood for eight or nine years before giving way. It was built upon a foundation consisting naturally of very compact hard-pan, overlaid by about 2 feet of coarse gravel and a few inches of soil. The embankment was formed of a washed and porous gravel obtained from a neighboring side-hill; it contained a little loam, but had nothing binding in its character, and was not suited to making into a puddle which should be impervious to water. The chief reliance had to be placed, for retaining the water, "* * * in the cement wall and the complete union of its base with the hard-pan; the main office of the embankment being to support and protect the wall." But the evidence showed that no efficient measures were taken to insure this complete union and thus to guard against percolation. The stored water was free from sediment, which, if present, might have been deposited so as to render the embankment water-tight. The embankment slopes were only $1\frac{1}{2}$ to 1, and its top was carried only 2 feet above the top of the wall, too slight a covering to guard against frost in this cold climate.

A great fault, moreover, seems to have existed in the inspection of the work, which was not skillful and was much of the time altogether lacking. The bottom of the wall was not even in all cases carried down to hard-pan; it was laid up dry and grouted 5 feet at a time; the mortar was poor and did not fill all the crevices. The soil and

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a Transactions of the American Society of Civil Engineers, Vol. III, paper No. xc.

porous gravel were only partially removed from the site of the dam. It is not surprising, therefore, in view of the various defects pointed out by the committee, and which have been briefly mentioned above, that when the trying time came the whole structure quickly collapsed. In speaking of the failure the committee said:

It is probably not possible to ascertain with certainty the immediate cause of the failure, but from the evidence obtained we can come to no other conclusion than that the water found its way under the wall at a point about 100 feet from the discharge-pipe, causing a slip in the embankment on the down-stream side of the center wall, which, being then unsupported, yielded to the pressure on the upper side, and, falling over, made a breach, which was rapidly enlarged by the wasting away of the embankment and the fall of other parts of the wall. It may be asked, if this was the immediate cause, why did it not happen before, when the reservoir was at a higher level? The answer, we think, would be that there has been a gradual working out of the gravel under and near the wall, and loose places or cavities formed, which, when they had attained a certain development, would suddenly lead to the failure.

The bed of the stream is largely composed of coarse granite and gneiss, and affords secure foundation for the dams, which are in most cases built of stone. Much the greater part of the fall of the stream, in the main portion of its course, is taken up and in use; but there yet remains some unimproved fall, probably much the best privilege being one at Leeds, with 35 feet available fall, owned by Mr. George P. Warner, of the Mill River Button Company. Mr. Warner holds it for sale, and has 30 or 40 acres of land adjoining. The privilege was formerly improved by a dam, part of which still stands in ruins; there is a rock ledge in each bank at its site. With 35 feet fall probably 140 horse-power could be realized, 12 hours in the day, during at least nine months in an average year.

There are some concerns, of moderate size, above Williamsburg, but the most important are from that point to the mouth, and are mentioned in the following list:

Principal water-privileges on Mill river from Williamsburg to the mouth.

Locality.	Firm.	Manufacture.	Fall.	Remarks.
			Feet.	
Williamsburg	H. L. James	Woolen goods	16	
Haydenville	Hayden Company	Brass goods	18	65 horse-power used in 1880.
Do	Lucius Briggs, Son, & Co.	Cotton goods	22	85 horse-power used in 1880.
Leeds	Nonotuck Silk Company	Sewing-silk, machine-twist, and knitting-silk.	30±	2 privileges.
Do	Mill River Button Company	Vegetable-ivory buttons	12	50 horse-power in use in 1880.
Do	Owned by G. P. Warner	Unimproved	35	For sale. Good power.
Florence	Greenville Manufacturing Company	Sheetings and drills	24	5,000 spindles.
Do	Nonotuck Silk Company	Sewing-silk, machine-twist, and knitting-silk.		
Bay State village	Northampton Cutlery Company	Cutlery	22	
Do	Clement Manufacturing Company	do	10	
Paper-mill village	Vernon Paper Company			
Northampton	C. A. Maynard	Hoes	14	120 horse-power used by Maynard in 1880, and 30 horse-power by concern for making tape.
Do	H. Lamb & Co.	Wire works	10	Power used from same privilege by grist-mill.

THE DEERFIELD RIVER.

In point of area drained, the Deerfield river ranks second among the tributaries of the Connecticut river, containing within its basin 646 square miles. It rises in the town of Stratton, in southern Vermont, and runs thence southerly into Franklin county, Massachusetts; $4\frac{1}{2}$ miles south of the Vermont line it turns, through fully ninety degrees, and pursues a somewhat southeasterly course, joining the Connecticut river a mile or so southeast of Greenfield.

The stream affords opportunity for developing a number of good privileges. It has a rapid fall, and at most seasons carries a considerable volume of water. It is not, however, assisted by storage reservoirs, and there are very few mill-ponds even, except in the upper waters. So far as could be learned there is not in Massachusetts a single natural pond of importance tributary to it; in Vermont there are shown on the maps half a dozen ponds of moderate size in the upper basin, but no information can here be given as to their true extent or value. The country drained by the Deerfield is hilly throughout, and even rises to mountains in the upper basin, where the slopes are very abrupt and rocky. Naturally, therefore, the stream runs very low in the dry season, and is subject, on the other hand, to sudden and extreme rises. After the storm of September 21–23, 1882, which was an unusually heavy one, drift was noticed that had been left 10 feet above low water on the bank near Charlemont, where the stream was of normal width and had a moderate current. On the Shelburne Falls dam, about 500 (?) feet long, the depth of water in that storm was estimated at about 6 feet, which has frequently been observed before.

The Fitchburg railroad follows the river closely from its mouth to Hoosac Tunnel, at which point the upper course of the river diverges. The New Haven and Northampton railroad also follows the lower river for a short distance, and then continues on to North Adams over the Fitchburg tracks. Although the stream is thus skirted

in the main part of its course by railroads, there are, with the exception of Shelburne Falls, no villages or local industries of much importance upon its banks; the adjoining country does not appear rich agriculturally, and settlement is rather sparse.

In a distance of over 40 miles from its mouth there are but three improved water-privileges on the Deerfield river—at Shelburne Falls, Hoosac Tunnel, and Readsborough. It is not easy to account entirely for the slight development of power on this stream, which seems as favorably situated as other streams that are much more used. It is not improbable, however, that the present rather fluctuating, wild, and unrestrained character of the river may have much to do in deterring manufacturers from improving it, so long as they can find other streams that are free from this disadvantage. The Deerfield is undoubtedly a violent river in freshets, and is visited by heavy runs of ice, but these are faults common to a great many New England streams in their natural state; they call for strongly-constructed works, but become much modified as the streams are built up with dams, and as storage reservoirs are developed to distribute through the dry season the melting snows and heavy rains of spring. Again, portions of the valley are undoubtedly too confined to accommodate villages of importance, or even mills; but there are numerous widenings where there is abundant room. As regards shipping facilities, it has already been mentioned that two lines of railroad reach the stream, and these give easy communication with three important points; the main portion of the course is distant, by the Fitchburg railroad, from 110 to 140 miles from Boston, and from 50 to 80 miles from navigation on the Hudson river at Troy, and by the New Haven and Northampton railroad the distance to New York is about 175 miles.

Table showing the fall in the Deerfield river.

[Authority for elevations: Profile of Troy and Greenfield railroad.]

Locality.	Distance above mouth.	Elevation of water-surface above sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Readsborough, Vermont	*a* 42.5	1,154				Elevation approximate. Fall said to be about 400 feet from Readsborough to Hoosac Tunnel dam.
			400	10	40.0	
Top of Hoosac Tunnel dam	32.5	754				
			186	5	37.2	
At Zoar bridge, 24½ miles west of Greenfield	27:5	568				
			396	18	22.0	
At Bardwell's bridge, 8½ miles west of Greenfield	9.5	172				
			46	[illegible]	9.2	
At Deerfield meadows, opposite old Deerfield	4.5(?)	126				

a Mouth of West branch.

For the lower 6 miles of its course the Deerfield runs through fertile meadows bordered on the east by high hills. The meadows are largely devoted to grass, but are also well cultivated in corn. The river here runs smoothly, and its bed appears to be sand and fine gravel. Immediately above the sharp turn in the vicinity of Wapping the hills close in on either side, and the river runs about 300 feet wide over a bed of coarse gravel and between high steep banks of gravel or rock. It now lies for some distance at the bottom of a deep and narrow valley too difficult of access to invite improvement; the carriage-road leaves the stream, and does not again approach it till near Shelburne Falls, but the railroads follow either bank high above the river, until they connect at Bardwell's. In the vicinity of Shelburne Falls the valley widens out, but continues flanked by high hills, their steep slopes covered with brush and young timber. The river here flows over a bed of gravel and bowlders, with ledge rock appearing at intervals in the bed and frequently in the banks.

About half a mile, by straight course, below Shelburne Falls, J. W. Gardner, esq., of that place, owns a water-privilege with the adjoining land. He would like to retain some interest in the privilege, but would offer liberal inducements to parties wishing to improve it. The stream here runs southerly and has a very rapid descent. The right bank shows a long and extensive exposure of granite rising 15 or 20 feet from the water. The left bank shows similar ledges, but they do not occur at the same time in both banks. Elsewhere the banks appear generally firm, with bowlders cropping out, but at one or two points the left bank is sandy. That bank is also steep and unsuited to building, while the right bank is succeeded by gently-sloping ground, of suitable character and sufficient extent for mills and a village. Just beyond this easy slope, and farther up the hillside, is the railroad. It was stated that the Fitchburg Railroad Company had offered to run a spur-track down to the grounds at its own expense if the power should be improved. It is a question as to how the privilege could best be developed. A ledge of rocks running across the stream offers a natural foundation for a dam, but the left bank is there sandy. If a canal of any considerable length were run, it is probable that rock would be encountered and blasting be necessary. Somewhat farther down stream the right bank is high and appears firm, while on the opposite side is a high granite ledge. The right bank rises about 25 feet from the water and is succeeded by fine level ground. Probably a dam 15 feet high could be built here, and the fall used at once without a canal. Mr. Gardner claims an available fall of 18 feet for his privilege, the power of which may be estimated as follows:

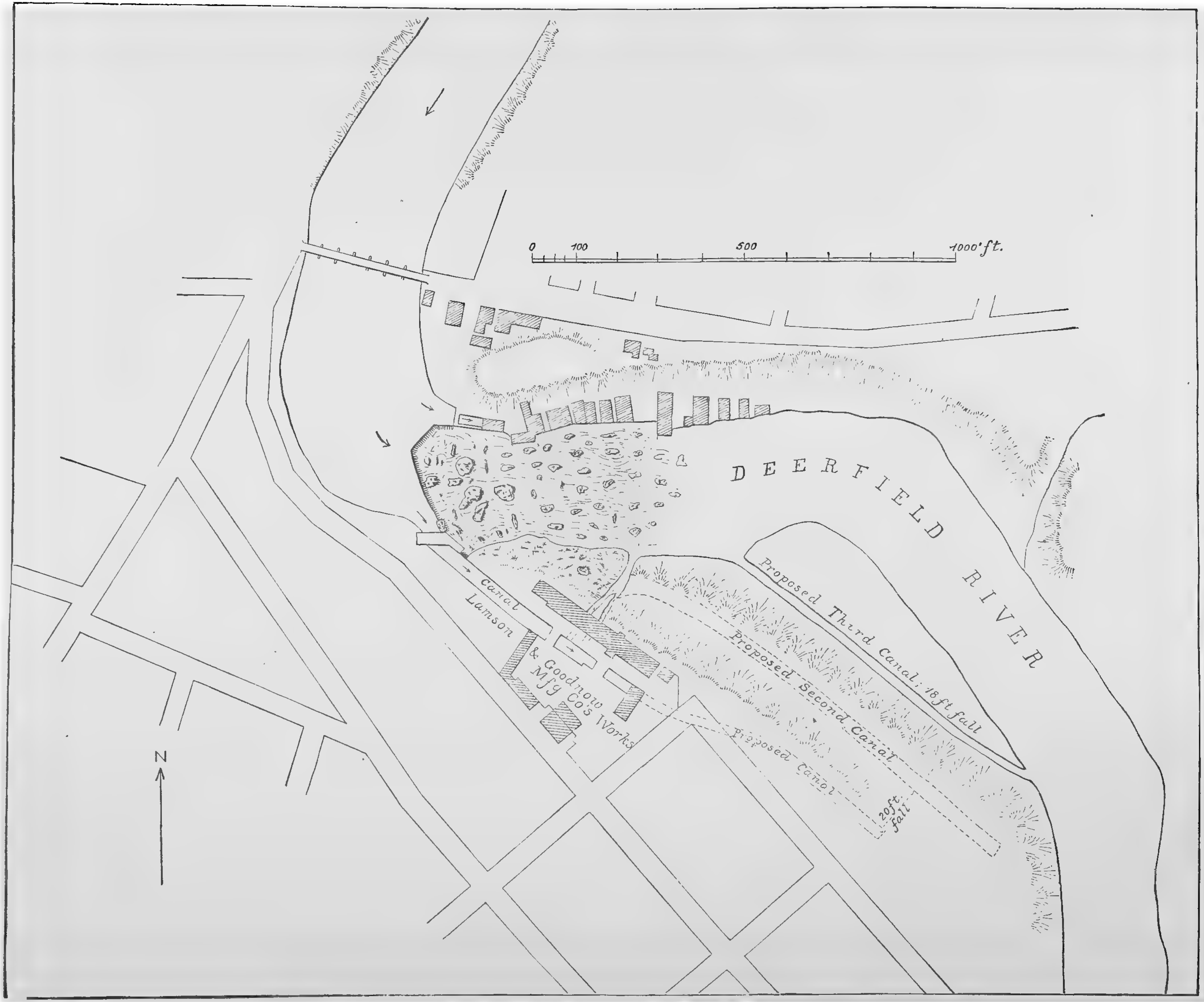

FIG. 24.—Water-Privilege at Shelburne Falls.

Estimate of power near Shelburne Falls.

Stage of river.	Rainfall on basin.					Drainage area (approximate).	Flow per second, average for the 24 hours. (a)	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	15 *feet fall.*	18 *feet fall.*
Low water, dry year							140	15.90	240	290
Low water, average year	11	13	12½	9½	46	475	190	21.58	320	390
Available 10 months, average year							290	32.94	490	590

a It is to be noticed that both here and above the village of Shelburne Falls the descent of the stream is so rapid that very little storage is to be obtained, and it is not therefore practicable to increase much, during the 10 or 12 working hours, the average flow for the 24 hours.

At the village of Shelburne Falls the water-power is owned almost entirely by the Lamson & Goodnow Manufacturing Company, employing 300 hands in the manufacture of cutlery. The dam runs across the river in an irregular line, convex up stream, and is built upon huge ledges of granite rock which are exposed largely at this point. It is built of logs, is perhaps 9 feet high, and cost approximately $7,000. The pondage is insignificant, extending back but a few hundred feet at the farthest. At the south end of the dam is a very heavy bulkhead of rubble and cement masonry, 18 or 20 feet wide on top, rising 10 feet above the ordinary water-surface and running inshore some distance to high ground. A short race leads to the mills, where power is taken from two overshot wheels, each of 125 horse-power, and a 100 horse-power turbine. These run under a head of 25 feet.

On the north side of the river are several small concerns. Frost & Bartlett rent power for a saw-, planing-, and 2-run grist-mill, but are shut down in low water. Just below there is a small tannery occasionally using a few horse-power; and, lastly, H. H. Mayhue has a small shop for making bits and gimlets, where he uses about 8 feet fall and, as stated, 25 horse-power. Mayhue claims a right to one-eighth the flow of the river, but in practice shuts down in low water for the benefit of the Lamson & Goodnow company. Throughout an average year this company can run its works at full capacity by water-power without hinderance, but in a very dry season, such as the summer of 1882, there is a little shortage for about two weeks, but both overshots can always be run.

FIG. 25.—Shelburne Falls, Deerfield river.

The dam was originally shorter than at present, and the bulkhead was subject to injury from high freshets and from floating ice, which, owing to a bend in the stream, naturally sets that way. In October, 1869, the water is estimated to have run 12 or 14 feet deep on the old roll-way, and the bulkhead and four of the buildings belonging to the Lamson & Goodnow works were carried away. The roll-way was subsequently extended 175 feet to its present length of perhaps 500 feet, and a strong bulkhead was built which seems capable of withstanding any force of the river. On the dam, as at present, the depth of water in an ordinary spring freshet does not exceed 3 feet.

There is a very rapid descent in the river below the dam, and from the top of that structure down to the foot of the principal rapids there is a fall of 70 feet, all owned by the Lamson & Goodnow company. There is thus a large amount of fall and power not in use, and this the company is willing to sell. Its present canal would not probably carry much surplus water beyond its own needs, but by extending the tail-race as a second level the water could be used over again, and there is a fair location for a mill.

Estimate of power on the Lamson & Goodnow Manufacturing Company's privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.				Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	25 *feet fall.*	55 *feet fall.*	70 *feet fall.*	
Low water, dry year		140	15.90	400	560	1,110	
Low water, average year	474	190	21.58	540	760	1,510	400–450
Available 10 months, average year		290	32.94	820	1,150	2,310	

From Shelburne Falls up to Hoosac Tunnel there is a pretty continuous shoal, with only occasional short stretches of quiet water. The bed and banks are gravelly, and the former seldom shows any considerable rock exposure. At Scott's bridge, however, a mile or so from Shelburne Falls, there is a rapid fall over rock; the stream is there narrow, confined between high banks, and the site for building is not very favorable. Between Shelburne Falls and Charlemont the valley is generally of fair width, and especially at East Charlemont and

vicinity it opens out finely, the hills receding from the river and leaving a splendid site for a village. Again, at Charlemont, at a point between there and Zoar, and at Hoosac Tunnel station, the valley widens out, and the stream is bordered by flat or gently-rising ground, ample for building-purposes. Elsewhere than at the localities mentioned the valley is generally narrow and inclosed by steep slopes.

Opposite Hoosac Tunnel station the river is about 150 feet wide. Just as the railroad strikes in toward the mountain the river bends sharply and comes from the north, and its valley soon becomes contracted and narrow as we ascend. The old state dam is perhaps 2,000 feet above the tunnel, at a point where the hills rise quite abruptly from the stream. At the west end the dam abuts on a huge ledge of outcropping rock, the strata of which are tilted almost vertical. At the opposite end the bank is gravel, and the abutment is of masonry, into which are built vertical ribs of timber, with plank-facing over all. The masonry is in very good condition, but the ribs are decayed and much of the planking is gone. The dam is a straight structure, the roll-way stated to be about 250 feet long and about 20 feet high above the river-bed; it is built of logs dressed and notched, and has a nearly vertical face, and an apron in three broad offsets of 30 or 40 feet each. Both the dam and apron are in fine condition. The bulkhead is of timber, built from one solid ledge to another, between which the canal was blasted out for a short distance.

The canal has a length of about a third of a mile, is from 25 to 30 feet wide and 8 feet deep. About midway of its length there is between it and the river a fine level piece of ground, perhaps 200 feet wide, and well suited to use for a mill-site. At the foot of the canal is a machine-shop of the Fitchburg railroad, with a small saw-mill adjoining. The water-wheels have a capacity of 225 horse-power, but only a small amount of this is actually in use. The head on the wheels is 29½ feet. The hydraulic works which have been described were originally built by the state of Massachusetts during the construction of the Hoosac tunnel, and the power was used for compressing air; 500 or 600 horse-power was in constant use, day and night, for that purpose. The superintendent of the machine-shop states that during the progress of the work referred to it was the experience that for two months in summer there was commonly only about enough water for 200 horse-power, but for most of the year abundance for the full capacity of all the wheels. The dam sets back the river about three-quarters of a mile, but when the power was in use for the compressors it was employed continuously and the pondage exerted no especial influence.

The privilege is said to be still owned by the state. The improvements are very substantial and render the power a valuable one. The ordinary spring-freshet rise on the dam is stated to be about 5 feet. There is usually a heavy run of ice in spring, and temporary gorges occur in the river below Hoosac Tunnel. Owing to a bend in the river above the dam, ice also piles up there, sometimes to a thickness of 25 or 30 feet.

Estimate of power at Hoosac Tunnel.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels now in place.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*29½ feet fall.*	
Low water, dry year	11	13	12½	9½	46	234	50	5.68	170	225 (Only partially used.)
Low water, average year							80	9.09	270	
Available 10 months, average year							130	14.77	440	

No knowledge was gained of any power being used on the Deerfield for 10 miles above Hoosac Tunnel, or until reaching Readsborough, Vermont. At that point the Deerfield River Company has recently made extensive improvements for the purpose of obtaining power for grinding wood pulp. A dam 40 feet high and 160 feet long at the crest has been built; it rests on rock, is 80 feet wide at the base, and is built up as a log crib-work, filled in with loose stone and covered with 6-inch planking. The back has a long slope; the face is vertical, or nearly so, except a short slope from the crest and an offset part-way down the front for breaking the force of overfalling water. The water is to be used in two falls, of 37 and 40 feet, respectively.

Estimated volume and theoretical power per foot fall at various points on the Deerfield river.

Locality.	Rainfall.					Drainage area.	Flow per second, average for the 24 hours.			Theoretical horse-power per foot fall.		
	Spring.	Summer.	Autumn.	Winter.	Year.		Low water, dry year.	Low water, average year.	Available 10 months, average year.	Low water, dry year.	Low water, average year.	Available 10 months, average year.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*			
Hoosac Tunnel	11	13	12½	9½	46	234	50	80	130	5.68	9.09	14.77
Charlemont, below Mill brook	11	13	12½	9½	46	338	80	120	190	9.09	13.63	21.58
East Charlemont	11	13	12	10	46	356	90	130	210	10.22	14.77	23.86
Shelburne Falls	11	13	12	10	46	474	140	190	290	15.90	21.58	32.94
Mill Village, 6½ miles from the mouth	11	13	12	10	46	536	160	220	330	18.18	24.99	37.49

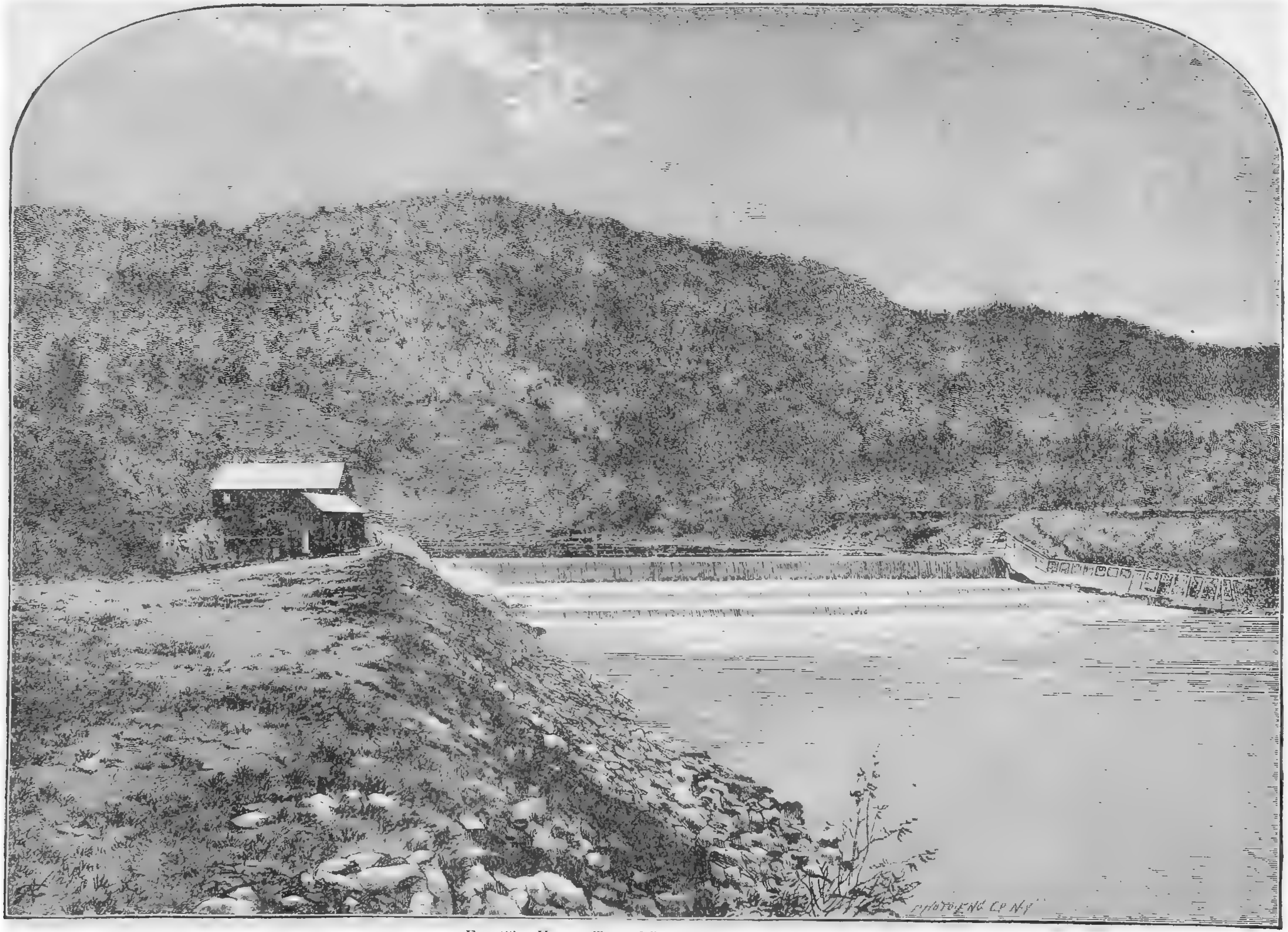

FIG. 26.—Hoosac Tunnel Dam, Deerfield river.

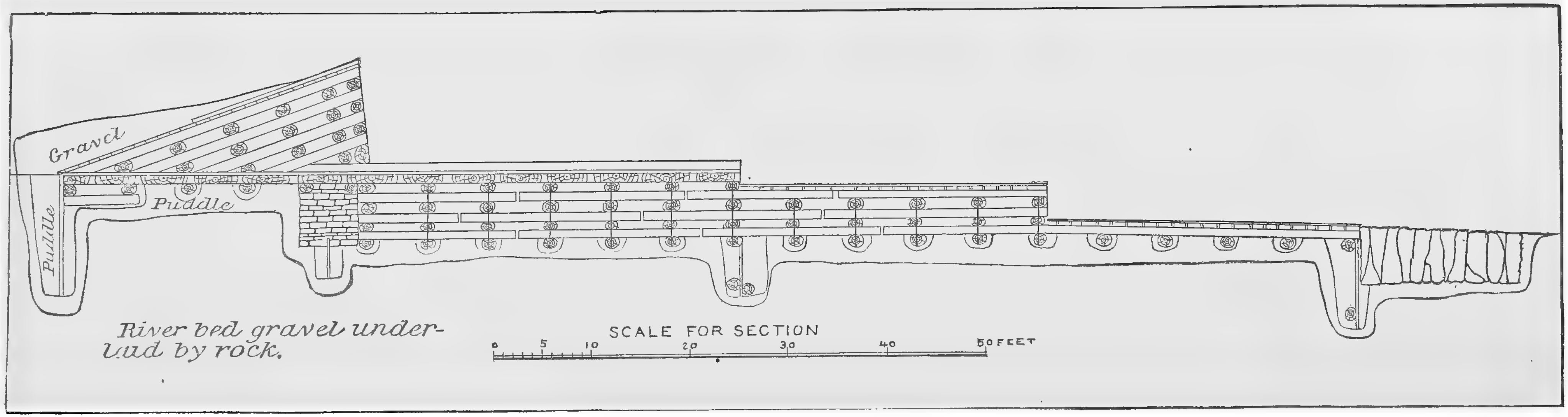

FIG. 27.—Cross-section of Hoosac Tunnel Dam.

MILLER'S RIVER.

The main stream may be regarded as formed in the town of Winchendon, in northern Worcester county, Massachusetts, by the union of branches from the town of Ashburnham and from lake Monomonac, the latter on the New Hampshire boundary. The river then pursues an irregular westerly course for about 32 miles, passing into Franklin county adjoining the Connecticut a little way above Turner's Falls. In its upper course it receives Otter river from the south and Tully river from the north, and those are its principal tributaries, although it is joined by numerous other minor streams. Its drainage area comprises 396 square miles, a small portion of which lies in New Hampshire. Although not a very large stream, Miller's river is a valuable one for milling purposes on account of its uniform and well-sustained volume. It is quite in contrast to the Deerfield river in this respect, as well as in the character of its valley, which is much more open, in general, and better suited to settlement. The fall is also large, amounting in round numbers to 600 feet from Royalston to the mouth, a distance of 23 or 24 miles.

Table showing the fall in Miller's river.

[Authority for elevations: Fitchburg railroad profile.]

Locality.	Distance from mouth. (a)	Elevation of water-surface above mean sea-level. (b)	Fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
First bridge west of South Royalston	23.1	768				
			93	2.0	46.5	
Second bridge west of South Royalston	21.1	675				
			184	9.6	19.2	
First bridge west of Orange	11.5	491				
			56	4.9	11.4	
Bridge between Erving and Miller's Falls	6.6	435				
			202	4.9	41.2	
Water above Miller's Falls dam	1.7	233				
			59	1.7	34.7	
Mouth of river	0.0	174				Estimated from elevation at Turner's Falls.

a Approximate.
b These elevations, as given by the Fitchburg railroad were referred to mean high water in Boston harbor, which is here assumed to be 5 feet above mean sea-level.

The area drained by Miller's river contains many ponds and lakes, the larger of which, with their approximate areas, are mentioned in the following list. There are said to be two or three storage reservoirs which are drawn upon to supply the stream in the dry season, but nothing definite could be learned regarding them. In particular, a large one is mentioned in the town of Winchendon, which is probably lake Monomonac.

List of the larger ponds and lakes tributary to Miller's river.

Locality (town).	Name of pond.	Approximate area.	Drains to what stream.	Authority.
Massachusetts.		*Acres.*		
Warwick	Pond east of Long pond	118	Moss brook	H. F. Walling.(*a*)
New Salem	Reservoir in northeast corner	320	Miller's river	Do.
Winchendon, Massachusetts, and Rindge, New Hampshire.	Monomonac lake	800	......do	Map of New Hampshire.(*b*)
Winchendon	Pond on Ashburnham line	100	......do	H. F. Walling.(*a*)
Do	Reservoir in south part	122	Otter river	Do.
Gardner	Crystal lake	216	......do	Do.
Ashburnham	Lower Naukeag pond	150	Miller's river	Do.
Do	Upper Naukeag pond	302	......do	Do.
Athol	White pond	100	......do	Do.
Phillipston	Reservoir on Athol line	130	......do	Do.
Petersham	......do	136	......do	Do.
New Hampshire.				
Rindge	Reservoir above lake Monomonac	100	......do	Map of New Hampshire.(*b*)
Do	Pearley pond	200	......do	Do.
Fitzwilliam	Sip pond	120	......do	Do.
Do	South pond	180	Tully river	Do.
Do	Meadow pond	120	......do	Do.
	Total of 16 ponds	3,214		

a See Appendix B, *Report of the Massachusetts State Board of Health*, 1873.
b Measured by planimeter.

The first water-privilege on Miller's river is close to the mouth, where Mr. James H. Brown, who resides near at hand, claims an available fall of 35 feet. Almost directly at the mouth there were once a saw- and a grist-mill, and part of the old log-dam is still standing. The bed and banks are there rocky and the stream has quite a pitch. A quarter of a mile above, the river is wider and its bed is crossed by a low ledge. Mr. Brown states that a dam 15 feet high at that point would flow an extensive swamp bordering the stream a little way above, and would give a fine storage. A canal could be carried from this site down the left bank to the mouth; any mill using the entire fall of the privilege would be located at the latter point and would discharge directly into the Connecticut river. This would, however, render it liable to occasional loss of head by high water in that river, the ordinary spring rise amounting to 10 or 15 feet. The land about the mouth is hilly and not especially favorable to the location of large mills; still there is a fair site for building on a point of land formed by the two rivers, and not owned by Mr. Brown. There is no village at this locality, though the privilege is conveniently situated at a distance of only half a mile from the New London Northern railroad, and about 4 miles by road from Turner's Falls; a road bridge crosses the river just above its mouth.

The power to be obtained on this privilege is an important one, and would have the benefit of the entire drainage area of the river. It does not seem, however, as though so large a fall as 35 feet is available. Judging by the elevations of the Fitchburg railroad the fall from the top of the Miller's Falls dam to the mouth of the river does not exceed 60 feet. Of this, 32 feet is included in the privilege at Miller's Falls, leaving say from 25 to 28 feet thence to the mouth unimproved. No gaugings of this river have been reported, but the power at Brown's privilege may be estimated as follows:

Estimate of power at the mouth of Miller's river.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power.			
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*15 feet fall.*	*25 ft. fall.* (b)	*35 ft. fall.* (b)
Low water, dry year	12	12	11½	10½	46	390	220	24.99	370	620	870
Low water, average year							260	29.54	440	740	1,030
Available 10 months, average year							300	34.08	510	850	1,190

a The flow and power as given could be materially increased during the ordinary working hours by the pondage here and above.
b See preceding remarks.

At Miller's Falls the river makes a decided bend and incloses a tract of quite level land. On the upper side of the bend the Miller's Falls Company has a dam about 175 feet long. It was built as a framed structure, but some thirteen years ago half of it was carried away and was afterward replaced by log-work; it has a sloping face and apron, planked over. A race some 700 feet long leads to the works of the Miller's Falls Company, manufacturer of general hardware, and especially of bits, braces, and vises. The main building measures 250 by 50 feet, and employment is given to 150 men. Two water-wheels, having a combined rated capacity of about 200 horse-power, are run under 16 feet head. The tail-water, instead of passing directly into the river, runs about 600 feet across the bend, and is again used by, first, the Lester & Lyman Manufacturing Company, hardware, using 16 feet fall and a 30 horse-power wheel; and, secondly, from the same level, by W. J. Phelps for a small grist-, saw-, and planing-mill and wheelwright shop. The Miller's Falls Company usually has sufficient water throughout the year, although in a low stage there is very little surplus. During the dry summer of 1882 the supply did not run short except on Monday mornings, and the scarcity then was due to the filling up, over Sunday, of the ponds along the river above. The pondage above the Miller's Falls dam is unimportant. The river is about 175 feet wide in this vicinity, and is considered to be very uniform in flow. The freshet depth on the dam is estimated not to exceed 3 feet.

About 100 rods above its dam the Miller's Falls Company owns an unimproved fall of 15 feet. A road bridge spans the river there, and just below on the west bank there is a good mill-site. Immediately succeeding this privilege, up stream, the same company owns an unimproved fall of 30 feet. Both these privileges are held for sale.

There is no dam on the river between Miller's Falls and Erving, although from the Fitchburg Railroad crossing below the latter point down to slack-water from the Miller's Falls dam there is a descent of 202 feet. As soon as we ascend above the village of Miller's Falls the river valley becomes narrow and is shut in by high hills which rise with abrupt slopes from the stream. This character is essentially retained till within perhaps 2 miles of Erving; there is then a fine site on the right bank, a wide meadow rising gently from the river. All the way between Miller's Falls and Erving the rapid fall of the river is easily seen as it comes rushing down impetuously over a gravelly bed. Although in this distance the valley is generally too narrow to accommodate with convenience extensive buildings or a village, still occasional points can probably be found where mills of moderate size might be located to advantage.

Estimate of unimproved power between Miller's Falls and Erving.

Stage of river.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power. 1 foot fall	15 feet fall.	30 feet fall.	200 feet fall.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*				
Low water, dry year	12	12	11½	10½	46	376–393	220	24.99	370	750	5,000
Low water, average year							250	28.40	430	850	5,680
Available 10 months, average year							290	32.94	490	990	6,590

a Mean for the section of river considered.

At Erving there is an old crib-work dam filled in with stone; it is built in two sections, making nearly a right angle up stream, and has a sloping face. A wooden bulkhead admits water to the race, which is several hundred feet long. The fall at the mills varies from 9 to 12 feet, according to position on the race. The power is used as follows: (1) E. H. Spring owns one-quarter of the privilege, and uses 9 feet fall and not to exceed 25 horse-power for a small grist-mill and in the manufacture of pail-staves. (2) The Washburn & Heywood Chair Company owns half the privilege, and uses 10 or 12 feet fall and 200 horse-power rated capacity of wheels in the manufacture of cane- and wood-seat chairs, sashes and doors, and wooden pails. Its production is about 600 chairs and 300 pails per day. (3) Noah Rankine owns one-quarter of the privilege, using 12 feet fall and, as he estimates, 50 horse-power in making wood-seat chairs. The Washburn & Heywood company, the largest user of power here, is commonly able to run its works at full capacity throughout the year.

From this point up to Athol, which is as far as the river was examined, the utilized powers succeed one another so closely as not to leave intermediate fall of sufficient amount to constitute a separate privilege. The surrounding country, which has hitherto been very hilly, now subsides and becomes level. The stream likewise grows flat, and is bordered by wide meadows, through which it flows between low banks. This character is most marked in the vicinity of Orange, and continues until beyond Athol, when hills of moderate height are again met and the fall becomes more rapid.

The first power above Erving is improved by a dry-stone dam capped with wood, a short race leading thence to the mill. The fall in use is 10 feet, but the proprietor claims that the dam can be raised 5 feet and a largely increased storage obtained at the same time. Power is used by J. Stone & Sons, manufacturers of piano-cases, of which they turn out $50,000 worth annually; and by J. Stone for a saw-mill. The site is a good one, with the railroad just across the river and a road bridge between. The horse-power in use was not ascertained, but it was stated to be but a small portion of the amount available with a tight dam. The surplus power is held for rent or sale. Chestnut, pine, and hard wood are the principal varieties of timber in this section, and the supply still holds good, though not of first quality.

Estimate of power at Stone's privilege (between Erving and Wendell Depot).

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 foot fall.	10 feet fall.	15 feet fall.	Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*				
Low water, dry year	368	210	23.86	240	360	*a* 115 (?)
Low water, average year		240	27.26	270	410	
Available 10 months, average year		270	30.67	310	460	

a Power in 1880, by census enumerators' returns.

NOTE.—The flow and power as here given can be considerably increased during the ordinary working hours.

The next power is at Wendell Depot, and is owned by the Goddard Pulp Company, which also leases power to the Farley Paper Company. The former of these also runs a pulp-mill, mainly for grinding spruce and poplar. Four double grinding-machines are operated, requiring about 200 horse-power; 35 hands are employed, and the production of the mill is about 2 tons of pulp and 2½ tons of paper per day. The Farley company makes principally card middles. The dam at this privilege is of crib-work filled with stone. It has a width of 40 feet at the base, is not far from 10 feet high, and rests partly on ledge rock and partly on gravel. The fall at the mill is 15 feet. A total of 375 horse-power is run 24 hours in the day, and even during the dry summer of 1882 there was always water enough for running at full capacity, except occasionally for a day or two when mills happened to shut down above. The dam now throws the water back about a quarter of a mile, but an addition of 5 feet to its height is contemplated, which would give a pond some 2 miles long, setting back nearly or quite to Orange.

Of the main privilege at Orange seven-eighths is owned without question by the New Home Sewing Machine Company; the remaining one-eighth is involved in some dispute. The dam is a very old log structure, and the stream above is so flat that backwater extends for 3 or 4 miles, or to the lower part of the village of Athol. The mills are located immediately adjacent to the dam, and obtain a fall of from 7 to 9 feet. The New Home company uses 100 horse-power of wheels and employs 525 men. This company is supplied with castings by the Orange Iron Foundery Company, and the two concerns are operated together; the latter employs 120 men. The Chase Turbine Manufacturing Company's works and Levi Kilbourn & Co.'s chair-factory also use small powers from the same privilege. The New Home company uses steam in low water, but for about ten months in the year can run by water-power alone. A short distance down stream a low wing-dam diverts water to the Orange Furniture Company's factory, where 3 or 4 feet fall and a small power are employed.

Athol, the next point on the river, is a large and pleasant village, and has quite a manufacturing interest sustained by the water-power of the river. In what may be considered the village proper there are four dams on Miller's river, in the following order, ascending:

1. In the upper part of the village the river divides so as to inclose an island. A low cheap dam across the left-hand channel turns water into a small race, which is carried over to the course of Mill brook, a little stream flowing through the place. Power is then obtained by damming this brook at two or three points so as to give successive falls. A little water is received from the brook, but the main dependence is upon Miller's river. There are three falls on the privilege. At the first C. F. Richardson has a small machine-shop, and is said to use an undershot wheel with 2 or 3 feet fall. The second fall is mainly owned by Ethan Lord, who runs in connection with it a small saw-mill and cloth-mill. W. Lord also has power for a 3-run grist-mill and an elevator, and the Downes & Adams Silk Manufacturing Company owns about 30 horse-power. The heads in use range from 8 to 10 feet. The third fall on the brook is used by the Athol Machine Company, which has 11 feet head and 33 horse-power, by the Athol Blanket Company, and by Fred. Cheney, manufacturer of cotton-batting.

2. The second privilege in order on the main river is improved by a log dam about 100 feet long built on a rock ledge, and is owned by the Athol Mill Company, running 4,000 spindles on satinet warps and towelings. This company has 17 feet fall and about 175 horse-power of wheels, but does not use more than half their capacity. A small power is rented to L. S. Sterret, who makes machinists' tools, and to George M. Gerry & Son for their machine-shop. A building has also been erected for the manufacture of sashes and blinds, to be supplied with power from this privilege, and there is still for rent surplus power, estimated at 75 horse-power in a low stage of water. The entire power of the privilege may be estimated as below:

Estimate of power at the Athol Mill Company's privilege.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*17 feet fall.*	
Low water, dry year	13	12	12	11	48	207	120	13.63	230	100±
Low water, average year							140	15.90	270	
Available 10 months, average year							160	18.18	310	

NOTE.—Pondage at points above is sufficient to increase considerably the flow and power here given, during part of the day, in low stages.

3. A short distance up stream a low dam of loose stones turns water into a race, from which it is drawn under about 12 feet head to furnish power for a couple of small saw-mills and a blind- and shutter-shop. Mr. James M. Cheney owns the privilege and would like to sell it. He states that here, as well as at other privileges in this vicinity on Miller's river, there is, on account of the small pondage, a scarcity of water in the forenoon at times during the dry season, it being held back through the night in the large pond at Royalston. With 12 feet fall, the theoretical horse-power of Cheney's privilege may be estimated as follows: In low water of a dry year, 160 horse-power; in low water of an average year, 190 horse-power; and for the amount available 10 months in an average year, 220 horse-power.

4. The last privilege in the village of Athol, and the farthest up stream which was examined, is owned by the Miller's River Manufacturing Company, which manufactures horse-blankets and satinets, and uses 17 feet fall and one wheel of 108 horse-power. This company estimates its fall equivalent to 250 horse-power in a medium low stage of river. The dam was built about the year 1867, rests on ledge rock, and has a roll-way about 20 feet high and 200 feet long; it is a log structure with sloping face, and is supplemented by about 300 feet of dry-stone work.

Summary of water-privileges on Miller's river, from Athol to the mouth.

Locality.	Firm.	Manufacture.	Fall.	Remarks.
			Feet.	
Athol	Miller's River Manufacturing Company.	Horse-blankets and satinets	17	Uses 108 horse-power.
Do	Power owned by J. M. Cheney	Power used by 2 saw-mills and a blind- and shutter-shop.	12	Privilege for sale.
Do	Power owned by Athol Mill Company.	Power used for manufacture of satinet warps and towelings, and by two machine-shops and a sash and blind factory.	17	Surplus power for rent.
Do	C. F. Richardson	Machine-shop	2–3	
Do	Ethan Lord	Saw-mill and cloth-mill		
Do	W. Lord	Grist-mill and elevator	8–10	These concerns are on the line of a race which strikes off from Miller's river to Mill brook, and then follows down the course of the latter, the falls given being those obtained on the race and brook.
Do	Downes & Adams Silk Manufacturing Company.	Silk		
Do	Athol Machine Company	Machine-shop		
Do	Athol Blanket Company	Blankets	11	
Do	F. Cheney	Cotton-batting		
Orange	Orange Furniture Company	Pine chamber suits	3–4	Small power obtained by wing-dam.
Do	New Home Sewing Machine Company.	Sewing-machines		
Do	Chase Turbine Manufacturing Company.	Turbines and circular saws	7–9	Seven-eighths of privilege owned by New Home Sewing Machine Company.
Do	L. Kilbourn & Co	Chairs		
Wendell Depot	Goddard Pulp Company	Pulp and paper	15	375 horse-power in use night and day, with nearly always sufficient water. An addition of 5 feet to the height of the dam is contemplated.
Do	Farley Paper Company	Card middles		
Between Wendell Depot and Erving.	J. Stone & Sons	Piano-cases and saw-mill	10	Turn out $50,000 worth of piano-cases yearly. Surplus power for disposal. It is stated that dam can be raised 5 feet.
Erving	E. H. Spring	Grist-mill, and makes pail-staves		Small power.
Do	Washburn & Heywood Chair Company.	Cane- and wood-seat chairs, sashes and doors, and wooden pails.	9–12	Owns half the privilege, and uses 200 horse-power of wheels. Turns out about 600 chairs and 300 pails per day.
Do	Noah Rankine	Wood-seat chairs		Uses small power.
Erving to Miller's Falls		Unimproved	200+	This is not all to be considered available for use, on account of the narrow character of the valley, but several good powers could undoubtedly be obtained; in particular at a point a mile or two below Erving, where there is a fine open site, and just above Miller's Falls, where the Miller's Falls Company owns two falls, of about 15 and 30 feet, respectively.
Miller's Falls	Miller's Falls Company	Bits, braces, and vises, and general hardware.		Employs 150 men. Privilege is in two falls of 16 feet each.
Do	Lester & Lyman Manufacturing Company.	Hardware	32	Uses tail-water from upper mill.
Do	W. J. Phelps	Grist-, planing-, and saw-mill and wheelwright-shop.		Do.
Mouth of river	Privilege owned by James H. Brown.	Unimproved	25±	One-half mile from New London Northern railroad and about 4 miles by road from Turner's Falls.

TRIBUTARIES OF THE CONNECTICUT RIVER IN NEW HAMPSHIRE AND VERMONT.

Above Miller's river the Connecticut receives numerous tributaries from either side in New Hampshire and Vermont, no less than fifteen of which drain upward of 100 square miles each. It is to be regretted that lack of time forbade any examination of these streams, otherwise than by visits to a few scattered points in the summer of 1880. As to the New Hampshire streams, a brief report upon their value and availability for water-power was made to the governor and council of the state in 1870 by three commissioners. In that report are included a general discussion as to the advantages presented by the state for manufacturing by water-power, and returns from various towns briefly setting forth the extent to which power was already in use, estimates of the number of available unimproved privileges, and occasionally some other data, such as the amount of fall to be obtained, or the position with reference to important markets. In Hitchcock's *Geology of New Hampshire*, published in 1874, much valuable information is contained bearing upon the water-power of the state. The climatology is reported upon, an extended series of elevations is given (many of them for points on the water-courses), and some facts are included as to the locations, approximate size, and altitudes of the principal lakes and ponds.

In the documents and official reports brought before the general assembly of Vermont in 1876 is a paper by Mr. Henry Clark, presenting a few facts concerning some of the streams in that state, and rehearsing the leading characteristics of the water-powers in almost exactly the same words employed in the New Hampshire report of 1870.

From these various sources of information, and from the results of personal examinations and inquiries, an attempt will now be made to give some of the principal data regarding the upper tributaries of the Connecticut. It is to be noticed that although many of these streams are short, flowing down drainage slopes which seldom depart more than 15 or 20 miles on the east, or from 25 to 30 miles on the west side, from the main river, their fall is large even at a

considerable distance below the head-waters. To illustrate by a single example: Sugar river, in New Hampshire, has its principal source in Sunapee lake, and thence to the mouth is an important mill stream; yet in its course of only 22 miles from the lake to the Connecticut river it descends 810 feet. The Connecticut river itself, in its course through and past New Hampshire, ranges in elevation above sea-level from 2,000 down to 200 feet, while, according to Dr. Hitchcock, its eastern water-shed line has an average elevation of nearly 4,000 feet from mount Madison to Moosilauke mountain, and of about 1,500 feet thence southward to the Massachusetts line. The lowest point in this entire line is stated to be at Orange summit, on the Northern railroad, where the altitude is 990 feet.

Of equal importance with the fall are the volume of water and the steadiness with which it is maintained. The mountainous, and often rocky, character of the surface in this part of the Connecticut basin of itself favors an uneven and poorly-sustained flow. But there are certain features which tend to offset the unfavorable condition of steep slopes, the principal of which are the greater rainfall of the elevated regions; the retaining of snow for a long time among the mountains and the gradual release of water by its melting; the wooded nature of a large part of the surface; the fact, stated by Dr. Hitchcock, that the "mountains, especially the higher summits, except where it has been destroyed by fire, are covered to a considerable depth by peat, formed chiefly from moss and lichens", which acts to interrupt the too rapid drainage of surface-water; and, in a very important degree, the presence of numerous natural lakes and ponds. Not only do these last in their natural condition have a very beneficial effect in holding back freshets, and by the warmth of their waters preventing, to a considerable extent, troubles from ice, but they also in many cases offer opportunity for raising their surfaces by dams, and for thus greatly enlarging their storage—such an important factor in the development of the New England rivers.

The principal streams of the section here described have convenient railroad communication with tide-water, the mountainous character of the country compelling the lines to follow the river valleys. The distances by rail of some of the more prominent points from important seaports and markets are shown below:

Distances by rail from tide-water of points in the upper Connecticut basin.

Locality.	To Portland.	To Portsmouth.	To Boston.	To New York.
	Miles.	*Miles.*	*Miles.*	*Miles.*
Keene, New Hampshire	....	....	90	210
Bellows Falls, Vermont	....	....	112	220
Claremont, New Hampshire	....	116	132	238
Lebanon, New Hampshire	....	124	140	265
Woodstock, Vermont	....	....	155	270
Saint Johnsbury, Vermont	136	....	189	321

Although, in the aggregate, a great number of water-privileges are in use on the New Hampshire and Vermont tributaries of the Connecticut, there can be no difficulty in finding good unimproved sites in almost any section; and it is true there, as elsewhere in New England, that many valuable privileges are occupied by small saw- and grist-mills which use but an insignificant part of the available power.

The Ashuelot river has a length by general course of from 40 to 45 miles, and a drainage area of 422 square miles. The main branch has its source on the northern boundary of the town of Washington, in Sullivan county, New Hampshire; it runs thence southwesterly and empties into the Connecticut in the town of Hinsdale, Cheshire county. Keene, with a population of 6,800, is the principal point on the stream. From Keene to the mouth the Ashuelot railroad follows closely the course of the river. The Ashuelot is sustained by several reservoirs controlled by mill-owners, and by a considerable number of natural ponds and lakes, the larger of which are mentioned in the table below. It is to be noticed that four of these, containing in the aggregate about 1,150 acres, have an average elevation of 1,300 feet above tide, or 1,100 feet greater than the mouth of the river.

Principal lakes and ponds in the basin of the Ashuelot river.

Name of pond.	Approximate area.	Elevation above sea-level.	Locality (town).	Outlet.
	Acres.	*Feet.*		
Sand pond (*a*)	172	....	Washington	Small stream to main river.
Ashuelot pond (*a*)	233	1,300	......do	Ashuelot river.
Munsonville pond	*b* 300	1,350	Nelson and Stoddard	Small stream to Otter river.
Woodward pond	*b* 230	1,300	Roxbury and Nelson	Roaring brook.
Breed pond	*b* 390	1,250	Harrisville and Nelson	Small stream to Pratt brook.
Monadnock lake	*b* 260	....	Dublin	Pratt brook.
Round pond (*c*)	150	....	Winchester	Small stream to main river.

a Storage reservoirs controlled by Messrs. Faulkner & Colony, of Keene; areas as stated by them.
b Measured by planimeter on Hitchcock's map of New Hampshire.
c Artificial reservoir controlled by stone dam 100 feet long and 15 feet high, built in 1873 at a cost of $3,200.

At the Cheshire Railroad crossing, near Keene, the water-surface of the river has an elevation of 469 feet above tide; the elevation at the mouth of the river is 206 feet, so that in the intervening distance of 21 miles, by river, there is a total descent of 263 feet, or an average of 12½ feet to the mile.

The country adjoining the river between the mouth and Keene is fairly well wooded. The valley is narrow at Hinsdale, but widens out above. At the former point the stream itself ranges from 100 to 200 feet in width. The bed and banks are usually gravelly, and the flow is quite well sustained.

Ascending the stream we find two water privileges in use at Hinsdale, but a short distance from the mouth. The lower is improved by a wooden dam 175 feet long and 10 feet high, built about 1860. A canal 250 feet long carries water to the Brightwood paper-mills, using 12 feet head and 75 horse-power, and to the cotton and woolen factory of Messrs. Haile, Frost & Co., using 12 feet head and 150 horse-power. The latter concern has sufficient water throughout the year, but the Brightwood mills are short at times.

At the upper privilege is a wooden dam, about fifty years old, 180 feet long by 6 feet high. A race perhaps half a mile long conveys water to Robertson & Son's paper-mill, to C. T. Amidon's cotton and woolen factory, and to two machine-shops. The fall in use ranges from 11 to 30 feet, and about 330 horse-power of wheels are employed.

At Turner's village and Ashuelot, power is employed in the manufacture of cotton-warps and beavers, and at West Swanzey are the Stratton woolen-mills, using 9 feet head and 200 horse-power. At Keene, Messrs. Faulkner & Colony have a woolen factory run by power from the Ashuelot. The dam is of wood, and is about 90 feet long and 15 feet high. Eleven feet head and 100 horse-power are in use at the factory.

Three and one-half miles above Hinsdale there is a stated to be a good unimproved privilege, where, with a canal 500 feet long, 27½ feet fall is available. The corresponding power may be estimated as follows:

Estimate of unimproved power 3½ miles above Hinsdale.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*27½ feet fall.*
Low water, dry year							125	14.20	390
Low water, average year	11½	12	12½	10½	46½	393	150	17.04	470
Available 10 months, average year							210	23.86	660

NOTE.—Pondage along the stream would, doubtless, considerably increase the power here during part of the day, but no data are at hand indicating to what extent.

On the main stream above Keene, and on various tributaries, are many minor privileges occupied by saw-mills, as well as an abundance of unimproved sites.

West river rises in the towns of Weston and Peru, Vermont, from 20 to 25 miles northwesterly from Bellows Falls. It runs southeasterly through Windham county, and empties into the Connecticut immediately above Brattleboro'. From Londonderry, in the upper waters, to the mouth, it is followed by the Brattleboro' and Whitehall division of the Central Vermont railroad. Its length is about 36 miles, and its drainage area 363 square miles. It is utilized for power by various wood-working establishments.

Williams river is a small stream emptying into the Connecticut from the Vermont side 3 miles above Bellows Falls. Drainage area, 103 square miles. The Central Vermont railroad follows the course of the stream on its way from Bellows Falls to Rutland. Power is used by a number of small saw-mills and wood-working establishments.

Black river rises in the town of Plymouth, Vermont, and runs southeasterly through the towns of Ludlow, Cavendish, Weathersfield, and Springfield, in each of which there are thriving villages where power is used. The manufactures embrace cotton and woolen goods, lumber, flour, and various articles of wood. The stream has a drainage area of 152 square miles, and in its course passes through a number of ponds. For a half-dozen miles in its middle course it is followed closely by the Central Vermont railroad, but elsewhere it is from 5 to 7 miles distant from it.

Sugar river has its principal source in Sunapee lake, a splendid sheet of water, 7½ miles long, and 2½ miles wide in the broadest part, lying upon the boundary between Sullivan and Merrimack counties, New Hampshire. The river runs westerly, with a length of about 22 miles, passing successively across the towns of Sunapee, Newport, and Claremont, in the latter of which it empties into the Connecticut. The drainage basin of the stream includes 272 square miles. The principal tributaries are Goshen branch, which joins the main stream from the south at Newport, and Croydon branch, entering from the north at Northville.

Sunapee lake has an area of about 5,900 acres, and an elevation above tide of 1,090 feet at low water and 1,103 feet at high water. It also receives the drainage from Otter pond, 270 acres, and Little Sunapee lake, 510 acres. On the Croydon branch is Eastman's pond, of about 280 acres. The drainage area above the outlet of

Sunapee lake is 47 square miles. The fine storage afforded by this great reservoir, and the large fall of about 800 feet thence to the Connecticut river, combine to render Sugar river a splendid manufacturing stream, well sustained in the dry season, and free from hinderances by freshets or ice. The Concord and Claremont railroad follows the stream most of the way from the lake to the mouth. A large amount of manufacturing is supported by the stream, comprising cotton and woolen goods, paper, flour, lumber, and a variety of wooden implements and wares.

Claremont, a few miles from the mouth, is the most important point on the stream. The entire town contains a population of 4,700, and within its limits are, as nearly as can be ascertained, the following water-privileges on Sugar river:

1. Several miles above Claremont village, possibly beyond the limits of the town, 20 feet fall, rated at 175 horse-power, unimproved.
2. In Claremont, upper privilege owned by Monadnock Mills, 7½ feet fall.
3. Lower privilege, 16½ feet fall, in use by Monadnock Mills, running 160 horse-power.
4. Privilege with 14 feet fall used by the Sullivan Machine Company, which owns 100 horse-power, but actually employs less than one-third that amount. The remainder of the privilege is said to be owned by the Claremont Manufacturing Company and the Monadnock Mills.
5. Privilege with 12 feet fall, one-half owned and used by the Claremont Manufacturing Company, paper. The remainder is occupied by the Home cotton-mill and Eastman's tannery, the latter not in operation.
6. Fall of 14 feet. Power used by saw-mill, grist-mill, stair-rail factory, and two novelty works.

The river here divides into two channels separated by an island. On one of these, a fall said to amount to about 60 feet (*a*) is but slightly used by small shops. Continuing on the main river, we have:

7. Fall of 22½ feet, owned by the Sugar River paper-mill; 150 horse-power used, and as much more not in use.
8. Old furnace privilege, about 10 feet fall, unimproved.(*a*)
9. Fall of 13 feet, not used.(*a*)
10. Fall of 8 or 10 feet, used by woolen-mill and hosiery-mill.
11. Lower falls, "undeveloped, and of somewhat uncertain value".(*a*)
12. "From this point to the site of the old Russell carpet-mill could probably be erected one or two dams, though the banks are not so favorable for that purpose as could be wished."(*a*)
13. Fall of 12 or 15 feet, not used.(*a*)
14. At West Claremont, 18 or 20 feet fall, used for paper-, saw-, and grist-mills.(*a*)

Ottaquechee river.—This stream rises near the western boundary of Windsor county, Vermont, and runs easterly across the towns of Bridgewater, Woodstock, and portions of Hartford and Hartland, joining the Connecticut 3 or 4 miles below White River Junction. It has a length of about 40 miles by general course, and a drainage area of 192 square miles. Woodstock village, having a population of 1,300, is the most important point on the stream, and is reached by a short line of railroad from White River Junction.

Only a little way from the mouth a high ledge crosses the river and forms an island in the center. A log dam has been built from either side of this island to the adjacent shore, and on the right bank is a small saw-mill, and on the left the satinet factory of the Ottaquechee Woolen Company. Nine sets of cards are run, and 300 horse-power of wheels used under a head of 26 feet.

Five or six miles up stream, at the village of Quechee, A. G. Dewey & Co. have a 6-set woolen-mill, and J. C. Parker & Co. one of 7 sets. At numerous other points along the course of the stream small powers are in use by saw-mills and various wood-working shops, where are manufactured such articles as agricultural implements, chairs, wooden handles, sashes, doors, and blinds.

The river is described as a good one for manufacturing purposes. It has a reservoir in its upper waters, and is well sustained in flow. The Ottaquechee woolen factory can be run at full capacity at all times, with unimportant exceptions; 2 or 3 feet of backwater is said to be experienced there during high freshets in the Connecticut.

A mile up stream the proprietors of this factory own a fall of 30 feet, which has been in use but is now unoccupied.

The descent of the river is rapid, amounting to an average of very nearly 30 feet per mile for the lower 30 miles of its course. The fall is shown more in detail in the following table, kindly furnished by Mr. Hosea Doton, engineer of the Woodstock railroad:

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a Report on the water-power of the state, made in 1870.

Table showing the fall in the Ottaquechee river.(a)

Locality.	Distance above mouth.	Elevation of water-surface above water in Connecticut river.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Pond in the river at Sherburne	30	883			
			3	111	39.5
Bowl factory near West Bridgewater	27	772			
			1	47	
Chair factory at West Bridgewater	26	725			
			3	66	32.0
Pond at Wood's mills	23	659			
			2	74	
Saw-mill pond	21	585			
			2	84	
Factory pond at Bridgewater	19	501			
			5	99	18.8
Daniels' machine-shop, West Woodstock	14	402			
			1	14	
Factory pond at Woodstock	13	388			
			4	68	20.1
Taftsville pond	9	320			
			3	73	
Parker's factory pond at Quechee	6	247			
			1	49	41.2
Factory pond at Dewey's mills	5	198			
			¼	52	
Railroad crossing near Dewey's mills	4¾	146			
			3¾	61	
Head of Wood's falls	1	85			
			¾	55	
Pond at Quechee falls	¼	30			
			¼	30	
Connecticut river, water-surface	0	0			

a Mr. Doton gives the elevation of the Connecticut river above sea-level as 305 feet. This does not agree with elevations obtained elsewhere, and therefore heights along the Ottaquechee are here given with reference to water-surface at its mouth.

The Mascomy river rises in the western part of the town of Dorchester, Grafton county, Vermont; it runs southerly for about 9 miles, then turns abruptly to the west, and a few miles farther on enters Mascomy lake, a fine sheet of water 4 miles long and from one-quarter to three-quarters of a mile wide. Issuing from the lake, the river resumes its westerly course to the Connecticut, passing across the town of Lebanon. It drains 148 square miles above the outlet of Mascomy lake, and 190 square miles above its own mouth.

The most important lakes and ponds in the drainage basin, with their approximate elevations above tide, and areas, are as follows:

Mascomy lake; elevation, 750 feet; area, 1,400 acres.
Crystal lake; elevation, 900 feet; area, 380 acres.
Hart's pond; elevation, 1,050 feet; area, 450 acres.
Goose pond; area, 370 acres.
Norris pond; elevation, 1,500 feet; area, 330 acres.

In the distance of 8½ miles from Mascomy lake to the Connecticut the river falls about 406 feet, or say 48 feet to the mile. The Northern railroad follows the stream through the principal part of its course, and at Lebanon station is at an elevation of 510 feet above tide.

Lebanon is an important village about 4 miles from the mouth of the Mascomy river, with a population of 2,000. Manufacturing by water-power is carried on there and at numerous other points along the stream, the productions including iron-castings, machinery, watch and clock materials, lumber, woolen goods, paper, and various articles in wood. In the report upon the water-power of the state made in 1870, it was stated that in the town of Lebanon the value of the work annually turned out by water-power was at that time half a million dollars. In the same report the discharge of the stream at the lowest stage was given as about 134 cubic feet per second. Messrs. Mead, Mason, & Co., at Lebanon, manufacturers of sashes, doors, and blinds, use 18 feet fall and 325 horse-power of wheels, and state that they have sufficient water throughout the year for running their works at full capacity.

There are reported to be several unimproved falls in Lebanon, two privileges improved and with buildings, but unoccupied, and two unimproved falls at East Lebanon.

White river rises in the towns of Hancock and Granville, Addison county, Vermont, runs southeasterly, receiving in succession the Third, Second, and East branches, and enters into the Connecticut at White River Junction. The Central Vermont railroad follows its course from the mouth to Bethel, and then passes up the Third branch. The stream has a drainage area of 623 square miles, ranking third in this respect among the tributaries of the Connecticut. Mr. Henry Clark, of Rutland, says of this stream: "From its source it runs slowly through a narrow tract of intervale until it arrives at Stockbridge, after which the current is very rapid until it reaches Bethel village. From Bethel to its mouth the channel of the river is from 16 to 18 rods in width, and the current generally rapid and the water shallow." As usual on the streams in this section, power is used by a number of saw- and grist-mills, and by blacksmithing, cooperage, and wood-working shops. There is said to be considerable available power in the village of Bethel.

The Ompomponoosuc river drains 123 square miles, mainly in Orange county, Vermont, and empties into the Connecticut river 4 miles above White River Junction. It is stated to offer fine facilities for the use of power, but is without railroad communication except at the mouth. A number of small powers are in use by saw-mills and shops.

Wait's river lies entirely in Orange county, Vermont, through which it runs southeasterly to the Connecticut river. It has a length of 15 or 18 miles by general course, and a drainage area of 156 square miles. It is without railroad facilities except as it is crossed at the mouth by the Passumpsic railroad. It furnishes power to a variety of small establishments, mainly in the town of Bradford, where there are reported to be numerous unimproved falls.

The Lower Ammonoosuc river is formed by small branches the most remote of which drain the western slope of mount Washington. It flows westerly and then southwesterly, with a length by general course of about 40 miles, and joins the Connecticut at Woodsville. Its basin includes 388 square miles. The principal affluents are from the south, and among these the most important are the South branch and the Wild Ammonoosuc. The Boston, Concord, Montreal, and White Mountains railroad follows the course of the stream throughout its length. On the lower river the principal points are Woodsville, at the mouth, population, 400; Lisbon, 800; and Littleton, 1,700. The fall is large, as seen in the following table:

Table showing the fall in the Lower Ammonoosuc river.

Locality.	Distance from mouth.	Elevation above tide.	Approximate fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Ammonoosuc station, base of mount Washington	45	2,668				Elevations by profile of Boston, Concord, Montreal, and White Mountains railroad.
			1,339	13	103.0	
Lower Ammonoosuc at mouth of Little river	32	1,329				
			922	32	28.8	
Mouth of river	0	407				Elevation as given in *Geology of New Hampshire*.

At present the river is not sustained by any storage reservoirs, and is very variable in flow, a heavy rain causing a large and rapid rise. The bed and banks are generally rocky, and the latter high, though between Woodsville and Bath there are some meadow-lands. Toward the mouth the width between banks is from 100 to 200 feet.

The manufacturing is mainly in the towns of Lisbon and Littleton, and is carried on by a number of saw-mills, grist-mills, tanneries, and wood-working shops of different kinds. The lowest privilege in use on the river is at Bath, where Conant & Co. have a pulp-mill; 14½ feet fall and 350 horse-power of wheels are in use here, and in low water the wheels can be run at about one-half capacity. Directly at the mouth of the stream there is an unoccupied privilege, formerly in use, where 8 or 10 feet fall might easily be obtained; and, according to the report on the water-power of the state, there are at least three other unimproved falls on the river within the limits of the town of Bath.

Wells river rises in a series of ponds in the towns of Groton, Peacham, and Marshfield, Vermont. It flows southeasterly to the Connecticut, into which it empties nearly opposite the Lower Ammonoosuc. It has a length by general course of about 15 miles and a drainage area of 94 square miles. Of the ponds mentioned in the upper waters the largest is Long pond, which has a length of over 2 miles, and a width of about three quarters of a mile in the broadest part. The stream is followed by the Montpelier and Wells River railroad, and is described as being generally rapid and affording good powers. Its present use is mainly confined to saw- and grist-mills, of which there are over a dozen along its course.

The Passumpsic river is made up by small branches rising in the northern part of Caledonia county, Vermont. It takes a southerly course through the county, and unites with the Connecticut in the town of Barnet. It is 25 or 30 miles long by general course, and drains an area of 485 square miles. The principal affluents are the East branch and Moose river from the east, and Miller's run, Sleepy river, Andric and Lee's brooks from the west. The Passumpsic railroad follows the course of the main stream throughout, while the Burlington and Lamoille line crosses the basin from west to east and runs up the valley of Moose river. The principal points on the main river are Saint Johnsbury, some 8 miles from the mouth, having a population of 3,400, and Lyndon, as much farther above, with 800 inhabitants.

The Passumpsic is described as a generally swift stream, well suited to manufacturing purposes, but subject to considerable fluctuations in volume. The country drained is well supplied with springs, however, and the dry-season flow of the stream is tolerably well sustained. The bed and banks are rocky, and the opportunities are fairly good for securing large pondage at dams.

The first power in use, ascending the stream, is at East Barnet, only a short distance from the mouth. A horseshoe-shaped dam crosses the river here on ledges over which there is a natural fall, and gives a head of 29 feet at Wilder & Co.'s mill. They manufacture wood-pulp from spruce, and use three wheels having a total capacity of about 1,100 horse-power. It is stated that this amount of power can be obtained nine months in an

average year, but for the remainder of the time there is a shortage, and in lowest water only about one-half capacity can be realized. Wilder & Co. own all of this privilege except 100 horse-power at the opposite end of the dam, which is used in part by J. D. Gould for the manufacture of croquet and chair stock.

Some of the more important powers above on the stream, so far as could be learned by correspondence, are as follows:

At Saint Johnsbury there is a fine privilege with 12 feet fall, only a small portion of the power of which is in use by the Saint Johnsbury Granite Company and a carriage-shop. The dam was built in 1854, is a log and stone structure about 250 feet long and 10 feet high, and is stated to have cost in all $30,000.

In Lyndon there are at least four important falls. Wilder's pulp-mill has 61 feet head and 1,500 horse-power. The A. A. Pierce & Son paper-mill returns 13 feet fall and 1,000 horse-power, which it is evident can be realized only a part of the year. The Lyndon Lumber Company has from 13 to 18 feet fall, a pond estimated at 100 acres, and uses 200 horse-power; and Burke's flouring-mill has 11 feet fall and 36 horse-power. Numerous other powers are in use on the main stream and its tributaries, principally by saw- and grist-mills and wood-working shops. Undoubtedly there are many available unoccupied powers on these streams, but only only two were mentioned in particular—one of 20 feet fall, which it was said could be obtained on the lower Moose river by a short canal, and one of 15 feet fall, 2 miles below Saint Johnsbury, the power of which may be estimated as follows:

Estimate of power 2 miles below Saint Johnsbury.

Stage of river.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 foot fall.	15 feet fall.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*		
Low water, dry year	9½	12	11	8½	41	410	120	13.63	200
Low water, average year							160	18.18	270
Available 10 months, average year							240	27.26	410

John's river and *Israel's river* are two streams heading 5 or 10 miles northwesterly from mount Washington and descending to the Connecticut. John's river drains 86 square miles, includes in its basin several ponds of 150 or 200 acres each, the most important being Long, Island, and Cherry ponds, and is followed by the Boston, Concord, Montreal, and White Mountains railroad, but is used only for two or three small saw-mill powers.

Israel's river drains 129 square miles, is without natural ponds in its basin or a railroad along its course, but is used for power by 8 or 10 saw- and grist-mills, a paper-mill, machine-shop, and one or two wood-working shops.

The Upper Ammonoosuc river heads in the Pond of Safety, in the town of Randolph, Coos county, New Hampshire, at an altitude of 1,975 feet above sea-level. It runs in an irregular northerly direction, and then turns to the west, reaching the Connecticut river in the town of Northumberland. Its drainage area includes 252 square miles, within which are the following principal ponds:

Larger ponds tributary to the Upper Ammonoosuc river.

Name of pond.	Area. (*a*)	Elevation above tide.
	Acres.	*Feet.*
Head pond	330	1,075
Percy pond	350	1,040
Potter's pond	360	1,025
Trio ponds	270	1,960

a By planimeter measurement on state map.

The principal tributaries of the river are Dead river, Philip's brook, and Nash's stream. The main stream is followed from the mouth to West Milan by the Grand Trunk railway. The only use of power is by a few saw-mills, a grist-mill, and a machine-shop.

Table showing the fall in the Upper Ammonoosuc river.

Locality.	Distance above mouth.	Elevation above tide.	Fall between points, approximate.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Feet.*	
Pond of Safety	33	1,975			Altitude as given by Dr. Hitchcock.
			960	56.5	
West Milan	10	1,015			Elevation of rails, Grand Trunk Railway.
			89	11.9	
Railroad crossing near Stark	8½	926			Water-surface by Grand Trunk Railway levels.
			60	10.0	
Railroad crossing near Groveton	2½	866			Water-surface by Grand Trunk Railway levels.

The Nulhegan river joins the Connecticut from the west, draining the northern portion of Essex county, Vermont. Its basin comprises 132 square miles. Its course is followed by the Grand Trunk railway, but no returns of power used are at hand.

Hall's stream, 88 square miles drainage area; *Indian stream*, 67 square miles; and *Perry stream*, 27 square miles, are small tributaries which the Connecticut receives from the north in the extreme upper part of New Hampshire. They are not directly reached by any railroad, and no information has been gained that they are in any way used for power, except that a single small saw-mill power is returned for Perry stream.

Table of utilized power on the Connecticut river and its tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	H. P.	H. P.	
Connecticut river	Long Island sound	Connecticut	Hartford	Paper	3	(a)	1,080		Windsor Locks.—Total water-power utilized, 1,800 to 1,900 horse-power.
Do	do	do	do	Iron and steel	1		250	170	
Do	do	do	do	Cotton	1		100		
Do	do	do	do	Hosiery	1		50		
Do	do	do	do	Silk	1		10		
Do	do	do	do	Wool grading and scouring	1				
Do	do	do	do	Rubber rollers	1		225		
Do	do	do	do	Machinery	3		36		
Do	do	do	do	Flour and grist	1		45		
Do	do	do	do	Saw	1		30		
Do	do	Massachusetts	Hampden	Paper bags	1	(b)	4		Holyoke. (Total water-power utilized at Holyoke and South Hadley Falls, in 1880, as here enumerated, 12,260 horse-power. In October, 1882, the amount in use was stated at about 15,000 effective horse-power.)
Do	do	do	do	Leather belting and hose	1		6		
Do	do	do	do	Brick and tile	1		16		
Do	do	do	do	Carpentering	1		15		
Do	do	do	do	Cotton	5		3,016	65	
Do	do	do	do	Cutlery and edge-tools	1		40		
Do	do	do	do	Fertilizers	1		10		
Do	do	do	do	Files	1		3		
Do	do	do	do	Flour and grist	1		80		
Do	do	do	do	Lithographing	1		1		
Do	do	do	do	Planing	1		40		
Do	do	do	do	Mattresses and spring beds	1		2		
Do	do	do	do	Mucilage and paste	1		10		
Do	do	do	do	Machinery	8		288		
Do	do	do	do	Paper	17		6,315	23	
Do	do	do	do	Rubber and elastic goods	1		60		
Do	do	do	do	Sashes, doors, and blinds	1		15		
Do	do	do	do	Screws	1		80		
Do	do	do	do	Shoddy	1		150		
Do	do	do	do	Silk	1		100		
Do	do	do	do	Steam fitting and heating apparatus	1		6		
Do	do	do	do	Wirework	2		140		
Do	do	do	do	Wood turning and carving	1		5		
Do	do	do	do	Wood-pulp	1		120		
Do	do	do	do	Woolen	4		663		
Do	do	do	do	Worsted	2		550		
Do	do	do	Hampshire	Cotton	1	26–32	250		South Hadley Falls, opposite Holyoke.
Do	do	do	do	Paper	2		275		
Do	do	do	Franklin	Cotton	1	(c)	75		Turner's Falls (Total water-power utilized in 1880, as here enumerated, 4,320 horse-power.)
Do	do	do	do	Cutlery and edge-tools	1		675		
Do	do	do	do	Leather-board	1		15		
Do	do	do	do	Paper	8		3,290		
Do	do	do	do	Machinery	1		50		
Do	do	do	do	Saw	1		215		Opposite Turner's Falls.
Do	do	Vermont	Windham	Agricultural implements	1	(d)	30		Bellows Falls.—Total water-power utilized in 1880, as here enumerated, 4,210 horse-power. Up to October, 1882, this amount had been increased, as nearly as can be ascertained, by introduction of two new mills and increasing the power at the old ones, to 7,040 horse-power, of which 6,847 was employed in paper manufacture.
Do	do	do	do	Flour and grist	1		98		
Do	do	do	do	Machinery	1		30		
Do	do	do	do	Paper	4		4,017		
Do	do	do	do	Picture-molding	1		20		
Do	do	do	do	Planing and sawing	1		15		

a Falls range from 20 to 26 feet.
b Total fall on Holyoke privilege, 56 to 59 feet, utilized from three levels.
c Falls range from 20 to 41 feet.
d Total fall on privilege about 52 feet, utilized from two levels.

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Connecticut river..	Long Island sound.	Vermont	Caledonia	Saw	1	12	360 to 450	....	McIndoe's Falls.
Do..............	...do	New Hampshire.	Grafton.......	Flour and grist	1				
Do..............	...do	Vermont......	Essex.........	Saw	1	10	120	....	
Do..............	...do	New Hampshire.	Coos	...do	2	21	80	....	
Do..............	...do	... do	...do	Flour and grist, saw, and starch.	1	10	100	....	
Salmon river.......	Connecticut river.	Connecticut	Middlesex	Cotton	1	17½	70	....	
Do..............	...do	...do	New London..	Paper....................	2	27	140	....	
Do..............	...do	...do	...do	Flour and grist	1	17	22	....	
Tributaries	Salmon river......	...do	Middlesex	Bells	7	61+	99	....	
Do..............	...do	...do	...do	Coffins and undertakers' goods.	4	74	235	30	
Do..............	...do	...do	...do	Cotton-duck	2	59	136	....	
Do..............	...do	...do	...do	Cotton twine and yarns...	10	275	477+	85	
Do..............	...do	...do	...do	Flour and grist	1	28	15	....	
Do..............	...do	... do	...do	Hardware	1	20	15	....	
Do..............	...do	... do	...do	Machinery................	1	12	10	....	
Do..............	...do	...do	...do	Paper....................	1	....	....	....	
Do..............	...do	...do	...do	Plated and britannia ware.	1	48	30	40	
Do..............	...do	...do	...do	Saw	3	75	80	....	
Do..............	...do	...do	...do	Thread and silk...........	1	20	....	....	
Do..............	...do	...do	New London..	Sashes, doors, and blinds..	1	10	10	....	
Do..............	...do	...do	Tolland.......	Flour and grist	1	25	16	....	
Do..............	...do	...do	Hartford......	...do	1	18	18	....	
Do..............	...do	...do	...do	Saw	3	62	59	....	
Hockanum river...	Connecticut river.	...do	Tolland.......	Cotton	5	254	1,300 to 1,400	840	Rockville (see description).
Do..............	...do	...do	...do	Envelopes	1				
Do..............	...do	...do	...do	Silk......................	1				
Do..............	...do	...do	...do	Woolen	6				
Do..............	...do	...do	...do	...do	1	24½	125	....	
Do..............	...do	...do	...do	Paper....................	1	10	40	....	
Do..............	...do	...do	Hartford......	Cotton	1	20	250	100	
Do..............	...do	...do	...do	Paper....................	7	104	1,167	500+	
Tributaries	Hockanum river..	...do	Tolland.......	Carpentering	2	20	38	....	
Do..............	...do	...do	...do	Cotton	2	38	60	60	
Do..............	...do	...do	...do	Flour and grist	[illegible]	46	110	....	
Do..............	...do	...do	...do	Saw	4	69	95	....	
Do..............	...do	...do	...do	Shoddy	2	71	120	....	
Do..............	...do	...do	...do	Woolen	1	21	60	40	
Do..............	...do	...do	Hartford......	Cotton	3	76	70	65	
Do..............	...do	...do	...do	Flour and grist	1	18	20	....	
Do..............	...do	...do	...do	Machinery................	1	9	10	....	
Do..............	...do	...do	...do	Needles and pins	1	10	8	8	
Do..............	...do	...do	...do	Paper....................	8	219+	292	297	
Do..............	...do	...do	...do	Silk......................	1	36	52	758	
Do..............	...do	...do	...do	Woolen	2	14+	40	65	
Farmington river..	Connecticut river.	...do	...do	Worsted..................	1	7½	96	....	Poquonock.
Do..............	...do	...do	...do	...do	1	9	400	50	Do.
Do..............	...do	...do	...do	Paper....................	1				Do.
Do..............	...do	...do	...do	... do	3	10–13	350	....	Rainbow.
Do..............	...do	...do	...do	Horse-blankets	1	8	16	....	Spoonville.
Do..............	...do	...do	...do	Silk......................	1	13	100	....	Tariffville (300 horse-power of wheels).
Do..............	...do	...do	...do	Flour and grist	1	5	40	....	Farmington.
Do..............	...do	...do	...do	Cutlery and edge-tools....	1	(*a*)	750	50+	Unionville (about 1,000 horse-power, total, leased in 1882).
Do..............	...do	...do	...do	Hardware	1				
Do..............	...do	...do	...do	Iron bolts and nuts	1				
Do..............	...do	...do	...do	Paper....................	4				
Do..............	...do	...do	...do	Turning..................	1				
Do..............	...do	...do	...do	Flour, grist, and saw.....	1	9½	50	....	Unionville; intermediate privilege.
Do..............	...do	...do	...do	Agricultural implements, edge-tools, etc.	1	20	1,150	(?)	Collinsville.
Do..............	...do	...do	Litchfield....	Cotton-duck, furniture, hardware, brass and iron foundery, grist and saw.	1	17	480±	....	Pine Meadow.
Do..............	...do	...do	...do	Machinery, castings, and tools.	1				

a Two levels, 18 feet fall from each.

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Farmington river	Connecticut river	Connecticut	Litchfield	Cotton	1	30	800	....	**New Hartford.**
Do	do	do	do	Cotton	1	18	170	100	**Colebrook river.**
Do	do	do	do	Rules	1	8	20	....	
Do	do	do	do	Paper	1	12	135	....	
Do	do	do	do	Saw	1	12	40	....	
Do	do	do	do	Sashes, doors, and blinds	1	7½	15	....	
Do	do	Massachusetts	Hampden	Saw	1	16	75	....	
Do	do	do	do	Tannery	1	12	24	....	
Do	do	do	Berkshire	Agricultural implements	1	9	24	....	
Do	do	do	do	Saw	7	83	214	....	
Do	do	do	do	Tannery	1	12	10	....	
Do	do	do	do	Wooden packing-boxes	1	12	35	....	
Do	do	do	do	Wood turning and carving	1	....	11	....	
Pequabuck river and tributaries.	Farmington river	Connecticut	Hartford	Brassware	1	22, 12	87	345	
Do	do	do	do	Carriage and wagon materials.	1	24	10	....	
Do	do	do	do	Clocks	6	75½	135	221	
Do	do	do	do	Cutlery and edge-tools	1	10	30	....	
Do	do	do	do	Flour and grist	2	28	41	....	
Do	do	do	do	Hardware	6	100	106	19	
Do	do	do	do	Hosiery	2	19+	57	65	
Do	do	do	do	Machinery	1	12	10	10	
Do	do	do	do	Saw	1	22	20	....	
Do	do	do	do	Saws manufactured	1	5½	25	....	
Do	do	do	do	Sewing-machine materials and repairs.	1	8	15	....	
Do	do	do	do	Stationery goods	1	8	15	....	
Do	do	do	do	Stencils and brands	1	11	16	....	
Do	do	do	do	Wood turning and carving	2	22	23	....	
Do	do	do	do	Watch and clock materials	5	71	36	20	
Do	do	do	Litchfield	Flour and grist	1	26	16	....	
Do	do	do	do	Iron castings	1	12	15	....	
Do	do	do	do	Saw	2	25	18	....	
Still river and tributaries.	do	do	do	Agricultural implements	5	82	444	120	
Do	do	do	do	Wooden packing-boxes	1	12	10	....	
Do	do	do	do	Coffins and undertakers' goods.	1	8	38	35	
Do	do	do	do	Clocks	1	18	72	....	
Do	do	do	do	Cutlery and edge-tools	3	71	170	50	
Do	do	do	do	Flour and grist	2	19	63	....	
Do	do	do	do	Furniture	1	15	70	....	
Do	do	do	do	Hardware	1	18	80	10	
Do	do	do	do	Iron bolts, etc	1	15	60	80	
Do	do	do	do	Iron forgings	2	37	73	75	
Do	do	do	do	Machinery	1	6	18	....	
Do	do	do	do	Needles and pins	1	9	54	40	
Do	do	do	do	Printing and publishing	2	....	6	....	
Do	do	do	do	Saw	3	68	40+	....	
Do	do	do	do	Springs	1	16	45	....	
Do	do	do	do	Tanneries	3	28	70	15	
Do	do	do	do	Turning	2	67	50+	....	
All other tributaries.	do	do	Hartford	Carriage and wagon materials.	1	7	15	....	
Do	do	do	do	Cutlery and edge-tools	1	24	24	....	
Do	do	do	do	Explosives and fire-works	1	8	100	30	
Do	do	do	do	Furniture	1	7	5	....	
Do	do	do	do	Flour and grist	5	72	119	8	
Do	do	do	do	Hardware	1	18	40	....	
Do	do	do	do	Machinery	1	13	25	....	
Do	do	do	do	Paper	1	28	24	10	
Do	do	do	do	Saw and cotton	1	6	56	....	
Do	do	do	do	Saw	19	326	555	....	
Do	do	do	do	Wood turning and carving	3	55	75	....	
Do	do	do	do	Wheelwrighting	1	....	5	....	
Do	do	do	do	Woolen	1	24	18	....	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	H. P.	H. P.	
All other tributaries.	Farmington river.	Connecticut	Litchfield	Agricultural implements	1	15	20	....	
Do	do	do	do	Blacksmithing	1	12	20	....	
Do	do	do	do	Flour and grist	2	13+	43	....	
Do	do	do	do	Iron forgings	1	8	25	....	
Do	do	do	do	Ivory and wood rules	1	13, 14	107	....	
Do	do	do	do	Saw	11	159	288	....	
Do	do	do	do	Wood turning and carving	3	41	57	....	
Do	do	Massachusetts	Berkshire	Agricultural implements	2	19	21	....	
Do	do	do	do	Cooperage	1	8	25	....	
Do	do	do	do	Furniture	1	10	8	....	
Do	do	do	do	Saw	7	140	123	....	
Do	do	do	do	Whips and lashes	1	....	15	....	
Scantic river and tributaries.	Connecticut river.	Connecticut	Hartford	Fertilizers	1	6	12	....	
Do	do	do	do	Flour and grist	5	65	265	....	
Do	do	do	do	Gunpowder	1	62½	300	240	
Do	do	do	do	Paper	1	12	42	....	
Do	do	do	do	Saw	3	33	55	....	
Do	do	do	do	Woolen	2	38	148	260	
Do	do	do	Tolland	Flour, grist, and saw	1	15½	27	....	
Do	do	do	do	Saw	3	67	70	....	
Do	do	do	do	Woolen	2	23	60	....	
Do	do	Massachusetts	Hampden	Flour and grist	1	20	18	....	
Do	do	do	do	Woolen	3	52	95	160	
Mill river	do	do	do	Cotton-waste	2	28	65	25	
Do	do	do	do	Fire-arms	1	32	175	100	
Do	do	do	do	Flour and grist	2	26½	100	....	
Do	do	do	do	Hardware	1	....	80	....	
Do	do	do	do	Silk	1	11	75	....	
Do	do	do	do	Woolen	1	10	60	....	
Westfield river and tributaries.	do	do	do	Baskets, rattan- and willow-ware.	1	11	9	....	
Do	do	do	do	Blacksmithing	1	10	12	....	
Do	do	do	do	Boots and shoes	1	16	32	....	
Do	do	do	do	Cigars	1	5	12	....	
Do	do	do	do	Cigar-boxes	1	6	22	....	
Do	do	do	do	Cardboard	1	30	31	....	
Do	do	do	do	Carpentering	1	24	6	8	
Do	do	do	do	Coffin-trimmings	1	....	....	....	
Do	do	do	do	Cotton	1	32	350	....	West Springfield.
Do	do	do	do	Cotton-waste	1	10	....	....	
Do	do	do	do	Emery-wheels	1	....	....	....	
Do	do	do	do	Findings	1	14	46	....	
Do	do	do	do	Flour and grist	5	67	220+	....	
Do	do	do	do	Furniture	2	20	60	....	
Do	do	do	do	Gunpowder	2	24	31	....	
Do	do	do	do	Kaolin and ground earths.	3	32	122	....	
Do	do	do	do	Machinery	2	25	62	....	
Do	do	do	do	Paper	5	80	} 1,412	540	
Do	do	do	do	do	a2	....			
Do	do	do	do	Printing and publishing	5	30+	7	....	
Do	do	do	do	Saw	8	98	233	....	
Do	do	do	do	Shoe-pegs, etc	1	9	....	....	
Do	do	do	do	Steam-heating apparatus	1	....	12	....	
Do	do	do	do	Tanneries	3	54	80	....	
Do	do	do	do	Thread	1	10	....	....	
Do	do	do	do	Toys and games	1	16	15	....	
Do	do	do	do	Watch and clock repairing	1	28	1	....	
Do	do	do	do	Whips and whip materials.	12	10+	18+	....	
Do	do	do	do	Wooden ware	1	8	12	....	
Do	do	do	Hampshire	Baskets, rattan- and willow-ware.	1	11	7	....	
Do	do	do	do	Children's carriages and sleds	1	10	14	....	
Do	do	do	do	Cooperage	2	60	45	....	
Do	do	do	do	Cutlery and edge-tools	1	14	6	....	

a West Springfield; fall stated above.

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Westfield river and tributaries.	Connecticut river.	Massachusetts.	Hampshire	Flour and grist	4	64	141		
Do	do	do	do	Furniture	1	12	8		
Do	do	do	do	Lock- and gun-smithing	2	32	50		
Do	do	do	do	Machinery	1	40	40		
Do	do	do	do	Paper	4	91	485	90	
Do	do	do	do	Saw	17	285	448		
Do	do	do	do	Tools	1	13	12		
Do	do	do	do	Wooden handles	5	71	94		
Do	do	do	do	Wood turning and carving	7	92+	193		
Do	do	do	do	Woolen	3	67	118	120	
Do	do	do	Berkshire	Blacksmithing	1	18	6	5	
Do	do	do	do	Cutlery and edge-tools	1	19	20		
Do	do	do	do	Flour and grist	1	18	32		
Do	do	do	do	Iron castings	1	19	6		
Do	do	do	do	Paper	1	27	50	20	
Do	do	do	do	Saw	4	66	90	65	
Do	do	do	do	Wood turning and carving	3	47	38		
Do	do	do	do	Wooden ware	1	30	12		
Chicopee river	do	do	Hampden	Agricultural implements	2		110	60	
Do	do	do	do	Carpet yarns, crashes, twines, and bagging.	4	30	700		Ludlow Manufacturing Company.
Do	do	do	do	Cotton	11	106	4, 902	1, 150	These mills are owned by four different companies, as follows: 4 by the Dwight Manufacturing Company, 4 by the Chicopee Manufacturing Company, 2 by the Indian Orchard Mills, and 1 by the Otis Company.
Do	do	do	do	Flour and grist	2		105	150	
Do	do	do	do	Machinery	1	9	66	17	
Do	do	do	do	Paper	1	13	513		
Do	do	do	do	Swords	1				
Do	do	do	do	Tools, sewing-machines, and bronze statuary.	1		100–200		
Quaboag river and tributaries.	Chicopee river	do	do	Flour and grist	2	23	35		
Do	do	do	do	Shoddy	1	10			
Do	do	do	do	Woolen	6	99	250	300	
Do	do	do	Worcester	Blacksmithing	1	5	4		
Do	do	do	do	Carriage and wagon materials.	2	14	20		
Do	do	do	do	Cotton	4	53	685		Including 3 mills at West Warren.
Do	do	do	do	Cutlery and edge-tools	1	12	80		
Do	do	do	do	Flour and grist	9	127	236		
Do	do	do	do	Saw	12	174	426		
Do	do	do	do	Wire	1	60	180		
Do	do	do	do	Wooden packing-boxes	2	33	45	60	
Do	do	do	do	Woolen	3	20+	210	60	
Ware river and tributaries.	do	do	Hampden	Cotton	2	39	610		Thorndike Company.
Do	do	do	Hampshire	do	3	63	750±	80	Otis Company.
Do	do	do	do	Flour and grist	1	11	20		
Do	do	do	do	Saw	1	11	25		
Do	do	do	do	Woolen	1	7			
Do	do	do	do	do	1		150		
Do	do	do	Worcester	Agricultural implements	3	40	44		
Do	do	do	do	Baskets	1	8	20		
Do	do	do	do	Chairs	5	132	96		
Do	do	do	do	Cotton	1	19	135		
Do	do	do	do	Flour and grist	7	100	228		
Do	do	do	do	Hats and caps	1	12	39	25	
Do	do	do	do	Hones and whetstones	1	12	8		
Do	do	do	do	Saw	24	340+	813	35	
Do	do	do	do	Tannery	1	8	30		
Do	do	do	do	Tools	1	16	15		
Do	do	do	do	Wheelbarrows	1	10	15		
Do	do	do	do	Wooden packing-boxes	1	14			

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Ware river and tributaries.	Chicopee river	Massachusetts	Worcester	Wood turning and carving	2	34	8	....	
Do	do	do	do	Woolen	2	38–40	600	125	Gilbertville.
Swift river and tributaries.	do	do	Hampden	Cotton	1	21	493	160	Bondsville.
Do	do	do	Hampshire	Agricultural implements	1	11	25	....	
Do	do	do	do	Cotton	1	8	35	....	
Do	do	do	do	Flour and grist	3	43	133	....	
Do	do	do	do	Saw	16	192	373	25	
Do	do	do	do	Sporting goods	1	22	15	....	
Do	do	do	do	Wooden packing-boxes	1	7½	12	....	
Do	do	do	do	Wood turning and carving	1	15	6	....	
Do	do	do	do	Woolen	2	27	150	35	
Do	do	do	Worcester	Billiard and bagatelle tables, cues, and materials.	1	7	25	....	
Do	do	do	do	Saw	6	63	181	....	
Do	do	do	do	Soapstone	1	20	125	....	
Do	do	do	do	Wooden packing-boxes	1	7	36	....	
Do	do	do	Franklin	Flour and grist	2	22	65	....	
Do	do	do	do	Saw	7	91	182	....	
Sundry small tributaries.	do	do	Hampden	Bricks and tiles	1	12	12	20	
Do	do	do	do	Flour and grist	2	29	88	....	
Do	do	do	do	Saw	2	40	45	....	
Do	do	do	do	Woolen	1	22	40	40	
Do	do	do	do	Worsted	1	9	45	45	
Do	do	do	Worcester	Woolen	3	76	195	195	
Mill river	Connecticut river	do	Hampshire	Agricultural implements	1	14	120	100	
Do	do	do	do	Brass goods	1	18	65	....	
Do	do	do	do	Buttons	4	54	109	85	
Do	do	do	do	Cotton	2	40	185	125	
Do	do	do	do	Cutlery and edge-tools	2	32	197	200	
Do	do	do	do	Emery-wheels	1	14	15	10	
Do	do	do	do	Flour and grist	2	27	67	....	
Do	do	do	do	Paper	1	....	....	....	
Do	do	do	do	Saw	1	18	33	....	
Do	do	do	do	Silk	3	....	100–200	85±	Nonotuck Silk Company.
Do	do	do	do	Tape	1	....	30	....	
Do	do	do	do	Wire-work	1	10	25	....	
Do	do	do	do	Woolen	1	16	115	50	
Deerfield river and tributaries.	do	do	Franklin	Bits and gimlets	1	....	25	30	
Do	do	do	do	Cotton	4	111	571	405	
Do	do	do	do	Cutlery and edge-tools	1	25	350	....	
Do	do	do	do	Files	1	16	6	....	
Do	do	do	do	Flour and grist	14	224	371	....	
Do	do	do	do	Hardware	1	32	22	....	
Do	do	do	do	Machinery	1	8	6	....	
Do	do	do	do	Musical instruments and materials.	1	8	25	....	
Do	do	do	do	Saw	28	473+	816	....	
Do	do	do	do	Tanneries	3	26+	28	15	
Do	do	do	do	Wood turning and carving	8	139	150	....	
Do	do	do	do	Woolen	1	18	50	40	
Do	do	do	Berkshire	Saw	1	29½	225	....	Hoosac Tunnel.—Full power of wheels as here given not in use.
Do	do	do	do	Machinery	1				
Do	do	Vermont	Windham	Children's carriages and sleds.	1	....	50	20	
Do	do	do	do	Chairs	1	20	25	....	
Do	do	do	do	Flour and grist	6	113	157	....	
Do	do	do	do	Furniture	1	24	45	....	
Do	do	do	do	Sashes, doors, and blinds	1	10	7	....	
Do	do	do	do	Saw	24	436	806	20	
Do	do	do	do	Tannery	1	10	10	15	
Do	do	do	do	Wheelwrighting	1	20	10	....	
Do	do	do	do	Wood turning and carving	2	29	24	....	
Do	do	do	Bennington	Furniture	5	93	274	40	

Table of utilized power on the Connecticut river and its tributaries—**Continued.**

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Deerfield river and tributaries.	Connecticut river.	Vermont	Bennington	Saw	5	86	199	....	
Do	do	do	do	Tannery	1	14	25	....	
Do	do	do	do	Wood turning and carving	1	9	35	....	
Do	do	do	do	Wooden ware	1	85	40	....	
Miller's river and tributaries.	do	Massachusetts	Franklin	Chairs	6	59	351	....	
Do	do	do	do	Flour and grist	4	22+	140	....	
Do	do	do	do	Furniture	3	23	57	....	
Do	do	do	do	Hardware	2	16	230	....	
Do	do	do	do	Iron castings	1	....	40	....	
Do	do	do	do	Machinery	1	....	15	....	
Do	do	do	do	Piano materials	1	10	100	....	
Do	do	do	do	Sashes, doors, and blinds	1	....	15	....	
Do	do	do	do	Saw	11	115+	292	....	
Do	do	do	do	Sewing-machines	1	8	100	40	
Do	do	do	do	Wood-pulp and paper	2	15	375	....	
Do	do	do	do	Wooden packing-boxes	3	38	67	....	
Do	do	do	do	Wood turning and carving	2	24	29	....	
Do	do	do	do	Wooden ware	2	....	33	....	
Do	do	do	do	Woolen	1	9	35	....	
Do	do	do	Worcester	Brooms and brushes	1	4	12	....	
Do	do	do	do	Chairs	22	335	866	540	Mainly on Otter river.
Do	do	do	do	Children's carriages and sleds.	2	26	97	20	
Do	do	do	do	Cotton	4	31+	187+	....	
Do	do	do	do	Fancy articles	1	14	10	....	
Do	do	do	do	Flour and grist	7	103	268	....	
Do	do	do	do	Furniture	6	112	170	95	
Do	do	do	do	Hardware	1	14	3	....	
Do	do	do	do	House-furnishing goods	1	7	5	....	
Do	do	do	do	Horse-clothing	1	8	2	6	
Do	do	do	do	Iron castings	2	15	25	....	
Do	do	do	do	Machinery	8	71	249	17	
Do	do	do	do	Matches	1	32	50	25	
Do	do	do	do	Paper	1	16	93	80	
Do	do	do	do	Painting and paper-hangings.	1	....	6	....	
Do	do	do	do	Sashes, doors, and blinds	3	24+	55+	....	
Do	do	do	do	Saw	30	398	1, 328	15	
Do	do	do	do	Shoddy	1	....	6	....	
Do	do	do	do	Silk	1	....	30	....	
Do	do	do	do	Tannery	1	10	50	....	
Do	do	do	do	Tools	1	....	....	....	
Do	do	do	do	Toys and games	3	26	52	....	
Do	do	do	do	Wheelwrighting	2	16	9	....	
Do	do	do	do	Window blinds and shades	2	30	80	....	
Do	do	do	do	Wooden packing-boxes	2	22	36	....	
Do	do	do	do	Wood turning and carving	2	25	22	....	
Do	do	do	do	Wooden ware	6	150	650	70	
Do	do	do	do	Woolen	5	72	518	95	
Do	do	New Hampshire	Cheshire	Cooperage	1	12	50	....	
Do	do	do	do	Flour and grist	2	22	54	....	
Do	do	do	do	Saw	16	236	543	65	
Do	do	do	do	Toys and games	1	14	15	....	
Do	do	do	do	Wheelwrighting	1	11	13	....	
Do	do	do	do	Wooden packing-boxes	3	36	58	60	
Do	do	do	do	Wooden handles	1	12	50	....	
Do	do	do	Hillsborough	Saw	1	12	31	....	
Ashuelot river and tributaries.	do	do	Cheshire	Agricultural implements	1	20	20	....	
Do	do	do	do	Brooms and brushes	1	8	10	....	
Do	do	do	do	Chairs	3	58	200	40	
Do	do	do	do	Cooperage	12	143+	248	45	
Do	do	do	do	Cotton	4±	....	....	....	Manufacture woolen goods also, and probably included in that class.

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Ashuelot river and tributaries.	Connecticut river.	New Hampshire.	Cheshire	Cutlery and edge-tools	1	7	30	....	
Do	do	do	do	Fancy and paper boxes	1	6	34	30	
Do	do	do	do	Flouring and grist	5	51	158	....	
Do	do	do	do	Hosiery, woolen	1	12	35	....	
Do	do	do	do	Iron bolts, nuts, washers, and rivets.	1	12	2	2	
Do	do	do	do	Iron castings	1	13	5	....	
Do	do	do	do	Machinery	3	44	70	....	
Do	do	do	do	Paper	2	34	244	....	
Do	do	do	do	Planing	2	27	32	....	
Do	do	do	do	Sashes and blinds	1	9	20	....	
Do	do	do	do	Saw	48	616	1,310	45	
Do	do	do	do	Stone and earthen ware	2	28	31	15	
Do	do	do	do	Tanneries	4	29	53	....	
Do	do	do	do	Toys and games	1	5	10	....	
Do	do	do	do	Wirework	1	16	12	....	
Do	do	do	do	Wooden packing-boxes	11	96	239	14	
Do	do	do	do	Wooden ware	3	43	75	....	
Do	do	do	do	Woolen	12	164	956	315	
Do	do	do	Sullivan	Saw	3	21	90	....	
Sugar river and tributaries.	do	do	do	Agricultural implements	1	12	65	....	
Do	do	do	do	Blacksmithing	1	10	15	....	
Do	do	do	do	Boot- and shoe-findings	1	7	9	....	
Do	do	do	do	Cooperage	1	....	2	....	
Do	do	do	do	Cotton	1	16½	300	....	
Do	do	do	do	Excelsior	2	26	120	....	
Do	do	do	do	Files	1	11	30	....	
Do	do	do	do	Flouring and grist	6	77	689	....	
Do	do	do	do	Hosiery	2	22	62	....	
Do	do	do	do	Iron castings	1	8	15	....	
Do	do	do	do	Leather tanned and curried.	3	36	75	....	
Do	do	do	do	Machinery	1	8	10	....	
Do	do	do	do	Paper	3	61	255	50	
Do	do	do	do	Printing and publishing	1	....	8	....	
Do	do	do	do	Saddlery and harness	1	11	30	....	
Do	do	do	do	Saw	26	345	836	....	
Do	do	do	do	Wood turning and carving	3	46	88	....	
Do	do	do	do	Wooden handles	3	23	65	....	
Do	do	do	do	Wooden ware	6	82	97	....	
Do	do	do	do	Woolen	5	62½	410	....	
Mascomy river and tributaries.	do	do	Grafton	Agricultural implements	1	13	20	....	
Do	do	do	do	Blacksmithing	1	....	5	....	
Do	do	do	do	Brooms and brushes	3	32	24	....	
Do	do	do	do	Carpentering	1	12	28	....	
Do	do	do	do	Cooperage	2	18	58	....	
Do	do	do	do	Flouring and grist	7	100	320	....	
Do	do	do	do	Furniture	1	12	120	....	
Do	do	do	do	Hosiery	2	20	42	....	
Do	do	do	do	Iron castings	1	12	20	....	
Do	do	do	do	Machinery	2	25	55	....	
Do	do	do	do	Marble and stone work	1	7	10	....	
Do	do	do	do	Mattresses and spring beds	1	8	60	....	
Do	do	do	do	Paper	1	12	50	33	
Do	do	do	do	Sashes, doors, and blinds	1	12	25	....	
Do	do	do	do	Saw	17	217	599	....	
Do	do	do	do	Tannery	1	8	30	....	
Do	do	do	do	Watch and clock materials	1	13	20	....	
Do	do	do	do	Wheelwrighting	2	24	60	....	
Do	do	do	do	Wooden ware	1	6	30	....	
Do	do	do	do	Woolen	1	12	....	....	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Lower Ammonoosuc river and tributaries.	Connecticut river.	New Hampshire.	Grafton	Agricultural implements	1	16	120	......	
Do	do	do	do	Carpentering	1	17	20	......	
Do	do	do	do	Carriages and wagons	1	10	25	......	
Do	do	do	do	Cooperage	1	10	45	......	
Do	do	do	do	Flouring and grist	5	76	228	......	
Do	do	do	do	Gloves and mittens	1	16	150	......	
Do	do	do	do	Leather tanned and curried.	2	32	175	......	
Do	do	do	do	Machinery	1	13	25	......	
Do	do	do	do	Mattresses and spring beds.	1	......	20	......	
Do	do	do	do	Musical instruments and materials.	1	......	20	......	
Do	do	do	do	Sashes, doors, and blinds	1	14	35	25	
Do	do	do	do	Saw	18	213	890	......	
Do	do	do	do	Shoe-pegs	1	12	100	......	
Do	do	do	do	Spools and bobbins	4	34	90	15	
Do	do	do	do	Starch	2	17	35	......	
Do	do	do	do	Wheelwrighting	1	6	8	......	
Do	do	do	do	Wooden packing-boxes	1	15	20	......	
Do	do	do	do	Wood-pulp	2	14+	520	......	
John's river	do	do	Coos	Sashes, doors, and blinds	1	10	12	......	
Do	do	do	do	Saw	2	......	150	310	
Do	do	do	do	Wheelwrighting	1	13½	6	......	
Israel's river and tributaries.	do	do	do	Carriages and wagons	1	10	30	......	
Do	do	do	do	Flouring and grist	2	24	140	......	
Do	do	do	do	Furniture	1	6	15	......	
Do	do	do	do	Machinery	1	7	20	......	
Do	do	do	do	Paper	1	14½	25	......	
Do	do	do	do	Sashes, doors, and blinds	2	14	30	......	
Do	do	do	do	Saw	14	153	661	40	
Do	do	do	do	Starch	2	28	28	......	
Do	do	do	do	Wheelwrighting	1	6	15	......	
Do	do	do	do	Woolen	1	8	10	......	
Upper Ammonoosuc river and tributaries.	do	do	do	Flouring and grist	2	24	65	......	
Do	do	do	do	Machinery	1	5	3	......	
Do	do	do	do	Saw	10	117	480	150	
Mohawk river	do	do	do	Cooperage	1	10	2	......	
Do	do	do	do	Flouring and grist	1	13	70	......	
Do	do	do	do	Furniture	1	8	8	......	
Do	do	do	do	Iron castings	1	8	8	......	
Do	do	do	do	Machinery	1	8	10	......	
Do	do	do	do	Sashes, doors, and blinds	2	16	18	15	
Do	do	do	do	Saw	2	[illegible]	60	......	
Do	do	do	do	Starch	5	69	40	......	
Do	do	do	do	Wheelwrighting	1	8	5	8	
Do	do	do	do	Woolen	1	10	12	......	
West river and tributaries.	do	Vermont	Windham	Carriages and wagons	1	6	8	......	
Do	do	do	do	Chairs	1	12	20	......	
Do	do	do	do	Cooperage	6	86	101	......	
Do	do	do	do	Flouring and grist	6	86	129	......	
Do	do	do	do	Furniture	1	10	9	......	
Do	do	do	do	Leather tanned and curried.	2	21	36	......	
Do	do	do	do	Pickles, preserves, and sauces.	1	12	23	......	
Do	do	do	do	Saw	28	369	844	30	
Do	do	do	do	Wheelwrighting	3	33	16	......	
Do	do	do	do	Wood turning and carving	5	110	88	......	
Do	do	do	Bennington	Carriage and wagon materials.	1	12	8	12	
Do	do	do	do	Saw	10	176	376	35	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total horse-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.			
West river and tributaries.	Connecticut river.	Vermont	Windsor	Cooperage	3	11+	47	....	
Do	do	do	do	Saw	6	28+	150	53	
Do	do	do	do	Toys and games	1	....	40	....	
Do	do	do	do	Wheelwrighting	1	....	15	....	
Do	do	do	do	Wooden handles	1	....	40	....	
Do	do	do	do	Woolen	1	20	20	....	
Saxton's river	do	do	Windham	Baskets, rattan- and willow-ware.	1	22	90	8	
Do	do	do	do	Carriage and wagon materials.	1	9	12	....	
Do	do	do	do	Flouring and grist	4	65	148	....	
Do	do	do	do	Leather tanned and curried.	1	20	25	....	
Do	do	do	do	Lumber planed	2	30	43	....	
Do	do	do	do	Marble and stone work	1	12	30	....	
Do	do	do	do	Saw	4	54	100	....	
Do	do	do	do	Wheelwrighting	1	11	12	....	
Do	do	do	do	Wood turning and carving	1	23	25	....	
Do	do	do	do	Woolen	2	45	95	58	
Williams river and tributaries.	do	do	do	Flouring and grist	1	18	75	....	
Do	do	do	do	Saw	1	18	25	....	
Do	do	do	do	Wood turning and carving	1	17	10	....	
Do	do	do	Windsor	Children's carriages and sleds.	1	10	12	....	
Do	do	do	do	Flouring and grist	3	54	106	....	
Do	do	do	do	Furniture	1	6½	8	....	
Do	do	do	do	Saw	2	34	85	15	
Do	do	do	do	Tannery	1	9	20	15	
Do	do	do	do	Wheelwrighting	1	7	10	....	
Black river and tributaries.	do	do	do	Agricultural implements	1	6½	22	....	
Do	do	do	do	Carpentering	1	87	42	....	
Do	do	do	do	Children's carriages and sleds.	3	39	156	....	
Do	do	do	do	Chairs	1	36	31	....	
Do	do	do	do	Cooperage	1	8	20	....	
Do	do	do	do	Cotton	2	43	121	....	
Do	do	do	do	Flouring and grist	13	208	441	....	
Do	do	do	do	Furniture	3	43	34	....	
Do	do	do	do	Hones and whetstones	1	18	15	....	
Do	do	do	do	Machinery	4	34½	44	15	
Do	do	do	do	Marble and stone work	1	10	20	....	
Do	do	do	do	Saw	18	315	646	....	
Do	do	do	do	Shoddy	1	28	40	....	
Do	do	do	do	Tannery	1	16	10	....	
Do	do	do	do	Toys and games	1	6	6	....	
Do	do	do	do	Wheelwrighting	1	10	5	....	
Do	do	do	do	Wood turning and carving	1	18	60	....	
Do	do	do	do	Wooden ware	3	42	70	....	
Do	do	do	do	Woolen	5	76	340	....	
Ottauquechee river and tributaries.	do	do	do	Agricultural implements	4	45	125	10	
Do	do	do	do	Chairs	3	26	65	....	
Do	do	do	do	Cooperage	1	8	20	....	
Do	do	do	do	Flouring and grist	4	57	215	....	
Do	do	do	do	Sashes, doors, and blinds	3	45	37	....	
Do	do	do	do	Saw	9	121	376	....	
Do	do	do	do	Tannery	2	32	60	25	
Do	do	do	do	Wooden handles	2	24	110	....	
Do	do	do	do	Woolen	4	85	590	50	
Do	do	do	Rutland	Saw	2	40	125	....	
White river and tributaries.	do	do	Windsor	Agricultural implements	2	15	53	....	
Do	do	do	do	Blacksmithing	3	29	36	....	
Do	do	do	do	Buttons	1	18	40	30	
Do	do	do	do	Chairs	1	11	75	....	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
White river and tributaries.	Connecticut river.	Vermont	Windsor	Cooperage	2	18	22		
Do	do	do	do	Flouring and grist	11	164	524		
Do	do	do	do	Hardware	1	7½	18		
Do	do	do	do	Lumber planed	[illegible]	53	72		
Do	do	do	do	Saw	28	394	939	25	
Do	do	do	do	Toys and games	1		20		
Do	do	do	do	Wheelwrighting	3	38	48		
Do	do	do	do	Wooden handles	2	16	50		
Do	do	do	Orange	Agricultural implements	5	53½	106		
Do	do	do	do	Blacksmithing	1	12	30		
Do	do	do	do	Carriages and wagons	1		8		
Do	do	do	do	Cooperage	1		31		
Do	do	do	do	Flouring and grist	6	65	287		
Do	do	do	do	Furniture	1	13	25		
Do	do	do	do	Leather tanned and curried.	2	21	18		
Do	do	do	do	Saw	14	179+	561		
Do	do	do	do	Wheelwrighting	2	9	150		
Do	do	do	do	Wooden handles	1	7½	8		
Do	do	do	do	Woolen	2	25	55		
Do	do	do	Addison	Saw	5	78	213		
Do	do	do	do	Woolen	1	8	12		
Do	do	do	Rutland	Flouring and grist	1	11	35		
Do	do	do	do	Saw	6	111	162		
Do	do	do	do	Wood turning and carving	1	17	20		
Ompomponoosuc river.	do	do	Windsor	Saw	1	10	60		
Do	do	do	Orange	Drugs and chemicals	1	16	50		
Do	do	do	do	Flouring and grist	1	8	30		
Do	do	do	do	Furniture	1	10	25	25	
Do	do	do	do	Saw	6	71	185		
Do	do	do	do	Sporting goods	1	10			
Do	do	do	do	Wheelwrighting	1	11	15		
Do	do	do	do	Woolen	1	30	40		
Wait's river and tributaries.	do	do	do	Blacksmithing	1	6	10		
Do	do	do	do	Cooperage	2	28	8+		
Do	do	do	do	Cordage and twine	1	15	32		
Do	do	do	do	Flouring and grist	6	93	131		
Do	do	do	do	Machinery	1	9			
Do	do	do	do	Sashes, doors, and blinds	1	18			
Do	do	do	do	Saw	13	174	341		
Do	do	do	do	Wheelwrighting	3	30	24+		
Do	do	do	do	Wood turning and carving	2	26	50		
Wells river and tributaries.	do	do	do	Blacksmithing	1	7			
Do	do	do	do	Flouring and grist	2	22	100		
Do	do	do	do	Furniture	1	7	25		
Do	do	do	do	Paper	1	18	70		
Do	do	do	do	Saw	3	38	110		
Do	do	do	do	Woolen	1	8	20		
Do	do	do	Caledonia	Flouring and grist	2	16½	68		
Do	do	do	do	Saw	7	100	235		
Passumpsic river and tributaries.	do	do	do	Agricultural implements	3	48	123		
Do	do	do	do	Carriages and wagons	1	8	40		
Do	do	do	do	Chair-stock, etc	1	29	100		
Do	do	do	do	Cutlery and edge-tools	1	10	4		
Do	do	do	do	Files	1	10	60		
Do	do	do	do	Flouring and grist	13	201	663		
Do	do	do	do	Furniture	2	26	36		
Do	do	do	do	Leather tanned and curried.	2	18	50		
Do	do	do	do	Machinery	2	32	45		
Do	do	do	do	Marble and stone work	2	40	40		
Do	do	do	do	Paper	2	25	1,090		

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	H. P.	H. P.	
Passumpsic river and tributaries.	Connecticut river.	Vermont	Caledonia	Sashes, doors, and blinds	2	28	61	....	
Do	...do	...do	...do	Scales and balances	2	38	135	175	
Do	...do	...do	...do	Saw	25	410	846	....	
Do	...do	...do	...do	Wheelwrighting	5	60	197	....	
Do	...do	...do	...do	Wood-pulp	3	107	2,750	....	
Do	...do	...do	...do	Wooden ware	3	37	135	....	
Do	...do	...do	...do	Woolen	2	28	58	....	
Do	...do	...do	Essex	Flouring and grist	1	12	50	....	
Do	...do	...do	...do	Saw	12	221	502	....	
Nulhegan river and tributaries.	...do	...do	...do	...do	1	12	240	....	
Minor tributaries	...do	Connecticut	Middlesex	Agricultural implements	2	128	250	....	
Do	...do	...do	...do	Brooms and brushes	2	64	26	....	
Do	...do	...do	...do	Buttons	1	8	8	....	
Do	...do	...do	...do	Coffins, burial-cases, and undertakers' goods.	1	11	10	....	
Do	...do	...do	...do	Cotton	3	59	250	550	
Do	...do	...do	...do	Cutlery and edge-tools	3	42	123	30	
Do	...do	...do	...do	Dyeing and cleaning	1	5	10	....	
Do	...do	...do	...do	Fertilizers	2	23½	31	....	
Do	...do	...do	...do	Flouring and grist	11	178	333	....	
Do	...do	...do	...do	Gunpowder	1	....	8	....	
Do	...do	...do	...do	Hardware	11	189	173	39	
Do	...do	...do	...do	Hooks and eyes	1	26	12	....	
Do	...do	...do	...do	Iron castings	1	....	5	....	
Do	...do	...do	...do	Ivory and bone work	7	125	143	80	
Do	...do	...do	...do	Lock- and gun-smithing	1	20	15	....	
Do	...do	...do	...do	Mattresses and spring beds	1	13	10	....	
Do	...do	...do	...do	Models and patterns	1	....	2	....	
Do	...do	...do	...do	Mosquito- and fly-nets	1	6	20	20	
Do	...do	...do	...do	Patent medicines and compounds.	3	51	20	....	
Do	...do	...do	...do	Sashes, doors, and blinds	1	13	10	....	
Do	...do	...do	...do	Saw	15	256	324	40	
Do	...do	...do	...do	Stationery goods	2	19	24	....	
Do	...do	...do	...do	Tools	7	125	213	....	
Do	...do	...do	...do	Washing-machines and clothes-wringers.	1	37	32	40	
Do	...do	...do	...do	Wheelwrighting	1	36	30	....	
Do	...do	...do	...do	Wirework	2	25	13	6	
Do	...do	...do	...do	Wood turning and carving	2	21	35	....	
Do	...do	...do	...do	Wooden handles	1	16	25	....	
Do	...do	...do	Hartford	Cigar-boxes	1	9	20	....	
Do	...do	...do	...do	Cotton	1	65	200	300	
Do	...do	...do	...do	Fertilizers	1	9	20	....	
Do	...do	...do	...do	Flouring and grist	18	310	426	80	
Do	...do	...do	...do	Furniture	1	15	10	....	
Do	...do	...do	...do	Hardware	1	32	115	....	
Do	...do	...do	...do	Hosiery	1	12½	27	25	
Do	...do	...do	...do	Iron forgings	2	56	55	....	
Do	...do	...do	...do	Mattresses and spring beds	1	13	6	....	
Do	...do	...do	...do	Needles and pins	2	38	21	3	
Do	...do	...do	...do	Paper	5	90	157	61	
Do	...do	...do	...do	Saw	8	112	155	....	
Do	...do	...do	...do	Soap and candles	1	20	15	....	
Do	...do	...do	...do	Tannery	1	12	20	....	
Do	...do	...do	...do	Tools	1	4½	10	60	
Do	...do	...do	...do	Watch and clock materials.	1	6	2	....	
Do	...do	...do	...do	Woolen	4	60+	186	140	
Do	...do	Massachusetts	Hampden	Fancy articles	1	19	30	40	
Do	...do	...do	...do	Flouring and grist	7	143	162	40	
Do	...do	...do	...do	Saw	4	15+	53	....	
Do	...do	...do	...do	Woolen	1	20	15	30	
Do	...do	...do	Hampshire	Buttons	2	40	35	....	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Minor tributaries	Connecticut river	Massachusetts	Hampshire	Children's carriages and sleds.	2	24	13	....	
Do	do	do	do	Cotton	3	60	226	580	
Do	do	do	do	Fire-arms	1	15	25	....	
Do	do	do	do	Flouring and grist	10	133	543	....	
Do	do	do	do	Lumber planed	2	16+	45	10	
Do	do	do	do	Machinery	1	7	8	....	
Do	do	do	do	Paper	6	166	457	210	
Do	do	do	do	Pumps	1	9	8	....	
Do	do	do	do	Rubber and elastic goods	2	41	110	110	
Do	do	do	do	Sashes, doors, and blinds	1	12	12	....	
Do	do	do	do	Saw	18	243	475	....	
Do	do	do	do	Silk	2	20	25	8	
Do	do	do	do	Tannery	1	20	8	....	
Do	do	do	do	Tools	1	10	10	....	
Do	do	do	do	Upholstering materials	1	22	20	....	
Do	do	do	do	Wheelwrighting	1	10	55	....	
Do	do	do	do	Whips	3	26	16	....	
Do	do	do	do	Wooden packing-boxes	2	35	50	12	
Do	do	do	Franklin	Agricultural implements	2	26	52	....	
Do	do	do	do	Chairs	1	12	14	....	
Do	do	do	do	Flouring and grist	11	269	254	....	
Do	do	do	do	Furniture	1	14	12	....	
Do	do	do	do	Sashes, doors, and blinds	2	28	20	....	
Do	do	do	do	Saw	30	557	834	20	
Do	do	do	do	Wheelwrighting	1	40	8	....	
Do	do	do	do	Wood turning and carving	2	26	50	....	
Do	do	do	do	Woolen	1	18	20	....	
Do	do	New Hampshire	Cheshire	Cutlery and edge-tools	1	10	10	....	
Do	do	do	do	Fancy and paper boxes	1	12	25	30	
Do	do	do	do	Flouring and grist	2	27	76	....	
Do	do	do	do	Paper	1	12	80	....	
Do	do	do	do	Planing	1	12	10	....	
Do	do	do	do	Sashes, doors, and blinds	2	43	40	....	
Do	do	do	do	Saw	15	198	387	10	
Do	do	do	do	Tin-, copper-, and sheet-iron ware.	1	9	60	....	
Do	do	do	do	Vinegar	1	....	20	....	
Do	do	do	do	Wheelwrighting	1	11	5	....	
Do	do	do	do	Wood turning and carving	1	14	40	....	
Do	do	do	Sullivan	Carriages and wagons	1	3	68	....	
Do	do	do	do	Coffins, burial-cases, and undertakers' goods.	1	7	10	....	
Do	do	do	do	Cooperage	2	23+	59	....	
Do	do	do	do	Flouring and grist	5	140	219	....	
Do	do	do	do	Saw	11	160	353	....	
Do	do	do	do	Shoe-pegs	1	9	55	....	
Do	do	do	do	Wooden handles	1	9	35	....	
Do	do	do	do	Woolen	2	31	54	....	
Do	do	do	Grafton	Flouring and grist	6	138	351	....	
Do	do	do	do	Hones and whetstones	3	29+	137	....	
Do	do	do	do	Paper	1	32	75	....	
Do	do	do	do	Saw	18	292	787	....	
Do	do	do	do	Starch	1	....	12	....	
Do	do	do	do	Tannery	1	25	20	....	
Do	do	do	do	Wheelwrighting	3	38	38	....	
Do	do	do	Coos	Flouring and grist	5	69	97	....	
Do	do	do	do	Saw	15	254	588	200	
Do	do	do	do	Starch	2	21	22	....	
Do	do	do	do	Wheelwrighting	1	20	30	....	
Do	do	Vermont	Windham	Blacksmithing	1	7	6	....	
Do	do	do	do	Chairs	1	11	25	15	
Do	do	do	do	Flouring and grist	6	121	186	....	
Do	do	do	do	Leather tanned and curried.	2	22	33	25	
Do	do	do	do	Machinery	2	36	24	....	

Table of utilized power on the Connecticut river and its tributaries—Continued.

Stream	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Minor tributaries	Connecticut river	Vermont	Windham	Needles and pins	1	17	40	....	
Do	...do	...do	...do	Paper	3	77½	155	70	
Do	...do	...do	...do	Saw	8	137	205	65	
Do	...do	...do	...do	Screws	1	8½	10	....	
Do	...do	...do	...do	Sewing-machines	1	17	40	....	
Do	...do	...do	...do	Wheelwrighting	1	14	3	....	
Do	...do	...do	...do	Wood turning and carving	3	35	43	....	
Do	...do	...do	Windsor	Agricultural implements	1	4	18	....	
Do	...do	...do	...do	Coffins, burial-cases, and undertakers' goods.	1	1	18	....	
Do	...do	...do	...do	Cotton	1	27	250	220	
Do	...do	...do	...do	Flouring and grist	6	121	219	....	
Do	...do	...do	...do	Iron castings	2	30	120	....	
Do	...do	...do	...do	Machinery	1	17	25	....	
Do	...do	...do	...do	Sashes, doors, and blinds	2	54	100	75	
Do	...do	...do	...do	Saw	6	125	201	....	
Do	...do	...do	...do	Tannery	1	20	30	....	
Do	...do	...do	...do	Wheelwrighting	2	25	16	....	
Do	...do	...do	Orange	Cutlery and edge-tools	1	....	....	....	
Do	...do	...do	...do	Flouring and grist	2	37	90	....	
Do	...do	...do	...do	Furniture	1	10	15	....	
Do	...do	...do	...do	Saw	5	80	190	....	
Do	...do	...do	Caledonia	Flouring and grist	3	31	175	....	
Do	...do	...do	...do	Leather tanned and curried.	2	27	18	12	
Do	...do	...do	...do	Sashes, doors, and blinds	2	21	30	....	
Do	...do	...do	...do	Saw	6	99	450	....	
Do	...do	...do	...do	Starch	1	10	6	....	
Do	...do	...do	...do	Wheelwrighting	3	49	33	....	
Do	...do	...do	Essex	Saw	8	115	513	30	
Do	...do	...do	...do	Woolen	2	....	16	....	

Summary of power utilized on the

[With a few unimportant exceptions this table is based upon the returns of the census enumerators, and represents the power in use in 1880. The

	River.	COTTON-MILLS. Number of mills.	COTTON-MILLS. Water-power utilized.	COTTON-MILLS. Auxiliary steam-power.	SILK-MILLS. Number of mills.	SILK-MILLS. Water-power utilized.	SILK-MILLS. Auxiliary steam-power.	WOOLEN-MILLS. (a) Number of mills.	WOOLEN-MILLS. (a) Water-power utilized.	WOOLEN-MILLS. (a) Auxiliary steam-power.	PAPER-MILLS. Number of mills.	PAPER-MILLS. Water-power utilized.	PAPER-MILLS. Auxiliary steam-power.
			H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
1	Connecticut river (main stream)	8	3,441	65	2	110		6	1,213		30	14,981	23
2	Salmon river and tributaries	13	683	85	1						3	140+	
3	Hockanum river and tributaries	11	725+	525+	2	77	758	10	1,125	635	16	1,499	797
4	Farmington river and tributaries	3	1,270	100	1	100		3	260		10	1,259	60
5	Scantic river and tributaries							7	333	420	1	42	
6	Mill river (Hampden county, Massachusetts)	2	65	25	1	75		1	60				
7	Westfield river and tributaries	3	350+					3	118	120	13	1,978	650
8	Chicopee river and tributaries	23	7,610	1,390				20	1,640	800	1	513	
9	Mill river (Hampshire county, Massachusetts)	2	185	125	3	100+	85	1	115	50	1		
10	Deerfield river and tributaries	4	571	405				1	50	40			
11	Miller's river and tributaries	4	187+		1	80		6	553	95	3	468	80
12	Ashuelot river and tributaries	4						12	956	315	2	244	
13	Sugar river and tributaries	1	300					5	410		3	255	50
14	Mascomy river and tributaries							1			1	50	33
15	Lower Ammonoosuc river and tributaries												
16	John's river												
17	Israel's river and tributaries							1	10		1	25	
18	Upper Ammonoosuc river and tributaries												
19	Mohawk river							1	12				
20	West river and tributaries							1	20				
21	Saxton's river							2	95	58			
22	Williams river and tributaries												
23	Black river and tributaries	2	121					5	340				
24	Ottaquechee river and tributaries							4	590	50			
25	White river and tributaries							3	67				
26	Ompomponoosuc river							1	40				
27	Wait's river and tributaries												
28	Wells river and tributaries							1	20		1	70	
29	Passumpsic river and tributaries							2	58		2	1,090	
30	Nulhegan river and tributaries												
31	Sundry small tributaries of Connecticut river	8	926	1,650	2	25	8	10	293	170	16	924	341
	Total, Connecticut river and all tributaries	88+	16,434+	4,370+	13	517+	851	107	8,378	2,753	104	23,538+	2,034

a Including also worsted-mills.

b Comprising blacksmithing shops, lock- and gun-smithing shops, brass and iron founderies, and establishments for the manufacture of agricultural implements, iron bolts and nuts, machinery, needles and pins, plated and britannia ware, pumps, saws, screws, scales and balances, sewing-machines and sewing-machine

c Comprising carpentering, cooperage, wheelwrighting, and wood turning and carving shops; planing-mills, and establishments for the manufacture of billiard carriages and sleds, coffins and undertakers' goods, excelsior, furniture, general house-furnishing goods, matches, models and patterns, picture-molding, piano

d Comprising bleaching and calendering, dyeing and cleaning, lithographing, marble and stone, calico printing, printing and publishing, soapstone, and wool and hose, boots and shoes, boot- and shoe-findings, bricks and tiles, brooms and brushes, buttons, carpet yarns, crashes, twines and bagging, cigars, cordage, drugs whetstones, hosiery, horse-blankets, kaolin and ground earths, leather board, linen, mattresses and spring beds, mosquito- and fly-nets, mucilage and paste, musical starch, stationery goods, tape, toys and games, upholstering materials, vinegar, whips and lashes, whip materials, wood-pulp, and wool extract.

e Power used mainly in the manufacture of wood-pulp.

NOTE.—In considering the results furnished by the above table, it should be borne in mind that while saw-mills stand first in number very small period, altogether, of the year. In reality, paper-mills far outrank all the other classes mentioned in the aggregate of water-Reckoning upon the same basis of working hours common among other mills, or, say, from ten to twelve hours, the total power utilized

Connecticut river and its tributaries.

aggregate has since been increased in a very considerable degree, as may be seen, for example, from the accounts of Holyoke and Bellows Falls.]

FLOURING- AND GRIST-MILLS.			SAW-MILLS.			VARIOUS METAL-WORKING ESTABLISHMENTS. (b)			VARIOUS WOOD-WORKING ESTABLISHMENTS. (c)			SUNDRY OTHER ESTABLISHMENTS. (d)			TOTAL.			
Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	
	H. P.	H. P.		H. P.	H. P.		H. P.	H. P.		H. P.	H. P.		H. P.	H. P.		H. P.	H. P.	
5	373	....	6	845	....	22	1,628	170	6	110	....	13	665	....	98	23,366	258	1
4	71	....	6	139	....	10	154	40	5	245	30	....	....	....	42	1,432	155	2
4	130	....	4	95	....	2	18	8	2	38	....	3	135	6	54	3,842	2,729	3
15	432	8	53	1,429	....	54	3,110	990	26	679	35	13	313	110	178	8,852	1,303	4
7	310	....	6	125	....	....	....	....	....	....	....	2	312	240	23	1,122	[illegible]	5
2	100	....	....	....	....	2	255	100	....	....	....	....	....	....	8	555	125	6
10	393	....	29	771	65	13	226	5	26	504	8	33	380	....	130	4,720	848	7
28	910	150	68	2,045	60	13	674	77	17	263	60	12	949	45	182	14,604	2,582	8
2	67	....	1	33	....	5	407	300	....	....	....	6	154	95	21	1,061	655	9
20	528	....	58	1,896	20	6	559	80	22	660	60	6	88	30	117	4,352	585	10
13	462	....	58	2,194	80	17	662	57	76	2,863	810	10	153	6	188	7,572	1,128	11
5	158	....	48	1,310	45	8	139	2	32	814	99	10	173	45	121	3,794	506	12
6	689	....	26	836	....	5	135	....	15	367	....	8	184	....	69	3,176	50	13
7	320	....	17	599	....	6	120	....	8	321	....	8	166	....	48	1,576	33	14
5	228	....	18	890	....	2	145	....	11	343	40	9	920	....	45	2,526	40	15
....	....	....	2	150	310	....	....	....	2	18	....	....	....	....	4	168	310	16
2	140	....	14	661	40	1	20	....	5	90	....	2	28	....	26	974	40	17
2	65	....	10	480	150	1	3	....	....	....	....	....	....	....	13	548	150	18
1	70	....	2	60	....	2	18	....	5	33	23	5	40	....	16	233	23	19
6	129	....	44	1,370	118	....	....	....	23	352	12	4	96	....	78	1,967	130	20
4	148	....	4	100	....	....	....	....	5	92	....	3	145	8	18	580	66	21
4	181	....	3	110	15	....	....	....	4	40	....	1	20	15	12	351	30	22
13	441	....	18	646	....	5	66	15	14	427	....	5	91	....	62	2,132	15	23
4	215	....	11	501	....	4	125	10	9	232	....	2	60	25	34	1,723	85	24
18	846	....	53	1,875	25	12	243	....	18	509	....	4	78	30	108	3,618	55	25
1	30	....	7	245	....	....	....	....	2	40	25	2	50	....	13	405	25	26
6	131	....	13	341	....	2	10+	....	8	82	....	1	32	....	30	506	....	27
4	168	....	10	345	....	1	....	....	1	25	....	....	....	....	18	628	....	28
14	713	....	37	1,348	....	9	367	175	14	569	....	7	e 2,840	....	85	6,985	175	29
....	....	....	1	240	....	....	....	....	....	....	....	....	....	....	1	240	....	30
91	3,131	120	167	5,515	365	54	1,463	138	57	1,126	152	51	925	342	456	14,328	3,286	31
303	11,579	278	794	27,194	1,298	256	10,547+	2,117	413	10,842	1,354	220	8,997	997	2,298	118,026	16,047	

bells, bits and gimlets, brass-ware, bronze statuary, clocks, coffin-trimmings, cutlery and edge-tools, files, fire-arms, general hardware, hooks and eyes, iron forgings, materials, springs, steam fitting and heating apparatus, stencils and brands, swords, tin-, copper-, and sheet-iron ware, watch and clock materials, wire, and wirework.
and bagatelle tables, cues, and materials, cigar- and packing- boxes, bobbins, carriages and wagons, carriage and wagon materials, chairs, chair-stock, children's materials, rules, sashes, doors and blinds, shoe-pegs, spools, washing-machines and clothes-wringers, wheelbarrows, wooden handles, and wooden ware.
grading and scouring works; tanneries, watch- and clock-repairing shops, and establishments for the manufacture of baskets, rattan- and willow-ware, leather belting and chemicals, emery-wheels, explosives and fireworks, fancy and paper boxes and other fancy articles, fertilizers, gloves and mittens, gunpowder, hones and instruments and materials, patent medicines and compounds, preserves and sauces, rubber and elastic goods, shoddy, soap and candles, spectacles, sporting goods,

and in the aggregate horse-power of wheels, a large proportion of them are not operated continuously, while many run during only a power actually employed, since, under ordinary circumstances, they are run day and night and continuously through the year. by paper-mills would probably correspond, in round numbers, to at least from 40,000 to 50,000 horse-power.

III.—THE QUINNIPIAC RIVER.

The Quinnipiac river has its source near the boundary line between the towns of New Britain and Farmington, Connecticut. Its entire length is about 35 miles. Most of the way it flows in a direction somewhat west of south, but in the lower part of the town of Southington it strikes southeasterly across a trap ridge which runs from the vicinity of New Haven northerly across the state; having crossed this ridge it resumes its former direction, and reaches Long Island sound through New Haven harbor.

The elevation of the track of the New Haven and Northampton railroad at the Quinnipiac crossing at Plantsville is 140.9 feet above mean low-tide at New Haven, indicating a probable average slope in the 25 miles from Plantsville crossing to the mouth of from 5 to 5½ feet per mile. The area drained by the Quinnipiac includes 156 square miles, and varies in width from 4 or 5 miles in the southern portion to about 13 miles in the latitude of Meriden. Although not large, the stream is regarded as well suited to manufacturing purposes. It is largely fed by springs and spring brooks which sustain its volume in the dry season.

The lower course lies through wide salt marshes, succeeded above Quinnipiac village by level meadows having a rather sandy soil. The valley is there broad and open, bordered by hills of moderate height. The first dam met in ascending the river is at Quinnipiac, a few miles from the mouth, and is a framed timber structure about 5½ feet high. The river-bed is there quicksand, and not only the dam but the masonry abutments rest on that foundation. Scour is prevented below the dam by loose stone, and in front of the west abutment by a plank apron. This abutment is 7 feet high, 9 feet wide at the base, 7 feet wide at the top, and is grouted throughout; it rises only slightly above the crest of the dam. The slope of the stream in its lower course being small, it readily chokes up during freshets, overflows the meadows and marshes, and rises so as to run smoothly over the top of the dam; it does not remain at a high stage, however, for more than a day or two. The fall at this dam is 6 feet. The only power in use is for a grist-mill and a small establishment manufacturing tire-bolts, blanks, and rivets. For the greater part of the year there is a moderate surplus power available for rent or lease. Mr. T. A. Todd, of Woodbridge, owns the privilege.

Estimate of power at Quinnipiac village.

Stage of river.	Rainfall.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	Inches.	Inches.	Inches.	Inches.	Sq. miles.	Cubic feet.	1 foot fall.	6 feet fall.	
Low water, dry year	11	11	11½	11	44½	153	60	6.8	40	30±
Low water, average year							80	9.1	50	
Available 10 months, average year							100	11.4	70	

At Wallingford the stream is from 50 to 75 feet wide. The lower privilege at this point is owned and occupied by the R. Wallace & Sons Manufacturing Company, manufacturers of flat table-ware, and employing 275 hands. This company has 7 feet fall, and obtains 125 horse-power by water during about one half the year, but uses steam-power in addition. The dam is stone at the base, with timber above. The head- and tail-races, and especially the tail-race, are long, having a combined length of from one-half to three-quarters of a mile.

Above the privilege just described the Oneida community has a fine power, where it has until recently manufactured spoons. Several small buildings, mainly of wood, are standing on the property, but when visited, in October, 1882, they were not in use, and it was reported that the community was desirous of selling all its property here. The dam is a substantial structure of stone, about 10 feet high and from 180 to 185 feet long between abutments. The latter, together with a pier at the center of the dam, serve to support an iron bow-string bridge. This dam was built in 1872, at a cost, including roll-way, abutments, and supplementary embankment, of $30,000. The privilege has a fall of 9 feet, and is especially valuable from the fact that there is a large storage above the dam, the area of the pond being stated at 110 acres—ample for storing the night-flow of the stream in low stages.

Estimate of power at Community privilege, Wallingford.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	Cubic feet.	1 foot fall.	9 feet fall.
Low water, dry year	110	40	4.5	40
Low water, average year		60	6.8	60
Available 10 months, average year		70	8.0	70

NOTE.—This privilege is one-half or three-quarters of a mile from the New York, New Haven and Hartford railroad, and 12 miles by that line from New Haven. Owing to the large pondage the power can be doubled for 12 hours in the day during low stages of the river.

The first manufacturing point above Wallingford is Yalesville, 3 miles distant. There are three powers in use here. At the lowest, Messrs. G. I. Mix & Co. manufacture spoons and hollow-ware, employing 80 hands. They use 9 feet fall and 100 horse-power. The dam is about 5 feet high, built of stone in cement and resting upon a gravel and rock foundation. The river-bed in this section is mainly gravel, and underlying it and the surrounding country is red sandstone. The remainder of the fall at this privilege, above the height of the dam, is gained by long races, the combined length of the head- and tail-races being about half a mile. By means of embankments these are protected from freshet waters overflowing from the river, and in high stages the head is increased nearly as much in the head-race as it is diminished in the tail-race, so that but little trouble is experienced.

At the middle privilege the Charles Parker Company manufactures britannia spoons. The dam here is curving in plan, and is constructed of cut stone resting upon a red-sandstone foundation. A short race leads to the mill, where the head is 9 feet and the rated capacity of the wheels is 150 horse-power, which, it is stated, can always be realized.

The L'Homme Dieu Hardware Company, employing 50 hands in the manufacture of augers, is located on the upper Yalesville privilege, where it uses 8 feet fall and 130 horse-power. The dam rests upon ledge rock, is of cut-stone masonry, 40 feet long, about 9 feet high, and was built in 1845. The head- and tail-races are each in the neighborhood of 1,000 feet long.

The next power is at Hanover village, and is used by the Meriden Cutlery Company. The dam is an old structure, which was rebuilt some years ago and had an apron added at a total cost of $5,000. The roll-way is 150 feet long, 20 feet high, and has a bold curve up stream; it rests upon a rock bed, and consists of cut-stone masonry surmounted by five successive layers of 12 inch square timbers. The fall is 20 feet, and 150 horse-power of wheels is in use. This is the second privilege to be noticed having a large storage, the flowage being estimated at 90 acres with an average depth of 5 feet. The large pondage is a great benefit to the mills at Yalesville, where the ponds are comparatively small, and enables them to realize much more power than they otherwise would.

Passing farther up stream, the Quinnipiac is utilized at several points in the town of Southington, but being so far in the upper waters the powers obtained are small.

Only one record of a measurement of the discharge of the Quinnipiac was found; this measurement was made in the latter half of 1879 for the Connecticut state board of health,(*a*) and showed a flow of about 160 cubic feet per second below the Hanover dam, with the wheels running at the mill and water just dripping over the top of the dam. The drainage area above this point is 97 square miles.

Mill river, which lies immediately west of the Quinnipiac, supplies the city of New Haven with water, and its flow has been observed. As stated by the superintendent of the water-works, the minimum flow is 12,000,000 and the ordinary summer flow 20,000,000 gallons per day, or, respectively, 19 and 32 cubic feet per second. With the drainage area of 56 square miles, these figures correspond to a minimum of 0.34 and to an ordinary summer flow of 0.56 cubic foot per second to the square mile.

Table of utilized power on the Quinnipiac river and its tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Quinnipiac river	Long Island sound	Connecticut	New Haven	Britannia and plated ware	8	25	375	125	
Do	do	do	do	Cutlery and edge-tools	1	20	150	......	
Do	do	do	do	Augers	1	8	130	......	
Do	do	do	do	Flouring and grist	1	} 6	{ 15	......	
Do	do	do	do	Iron bolts, etc	1		{ 15	......	
Do	do	do	do	Saw	1	....	50	......	Probably operated in connection with other works.
Do	do	do	Hartford	Cutlery and edge-tools	1	10	15	......	
Do	do	do	do	Flouring and grist	1	8	75	......	
Do	do	do	do	Hardware	3	33	109	50	
Do	do	do	do	Iron bolts, nuts, washers, and rivets.	1	5½	28	38	
Do	do	do	do	Saw	2	19	90	......	
Tributaries	Quinnipiac river	do	New Haven	Agricultural implements	1	16	20	40	
Do	do	do	do	Brass and copper, rolled	1	24	400	(?)	
Do	do	do	do	Britannia and plated ware	1	10, 21	120	120	
Do	do	do	do	Carriage and wagon materials.	3	35	34	15	
Do	do	do	do	Cutlery and edge-tools	2	20+	62	80	
Do	do	do	do	Fire-arms	1	60, 80	100	430	
Do	do	do	do	Flouring and grist	2	19	78	......	

a See page 59, report for year ending November 31, 1879.

Table of utilized power on the Quinnipiac river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Quinnipiac river	Connecticut	New Haven	Saw	3	64	54	......	
Do	...do	...do	...do	Tools	1	13	13	......	
Do	...do	...do	...do	Wooden handles	1	16	25	......	
Do	...do	...do	Hartford	Buttons	1	5	6	......	
Do	...do	...do	...do	Fancy articles	1	4½	8	......	
Do	...do	...do	...do	Hardware	2	40	150	......	
Do	...do	...do	...do	Iron bolts, nuts, washers, and rivets.	2	27	65	20	
Do	...do	...do	...do	Saw	1	24	23	......	
Do	...do	...do	...do	Wood turning and carving	1	5	8	......	

IV.—THE HOUSATONIC RIVER AND TRIBUTARIES.

THE HOUSATONIC RIVER.

This important stream is formed by small branches rising in the northern central part of Berkshire county, Massachusetts; it flows southerly through that county, passes down across Litchfield county, Connecticut, then constitutes the boundary between the counties of New Haven and Fairfield, and empties into Long Island sound 4 miles east of Bridgeport. The principal tributaries are the Naugatuck, Pomeraug, and Shepaug rivers, which join the main stream from the east in its lower course; numerous minor streams are also received, many of which are fed by large ponds and lakes. The Housatonic has a drainage area of 1,933 square miles, and a length by general course of about 110 miles; the actual distance from Pontoosuc lake, near Pittsfield, to the mouth, following the river closely, is at least 125 miles. Navigation extends to Birmingham, about 11 miles from the sound.

The fall of the river is large, amounting to nearly 1,000 feet from Pittsfield to the mouth; it is generally in the form of gravelly shoals, alternating with stretches of quiet water, but is occasionally interrupted by abrupt falls over rock, as at New Milford, Bull's Bridge, and Falls Village.

Table showing the fall in the Housatonic river.

Locality.	Distance above mouth.	Elevation above tide.	Fall between points.	Distance between points.	Average fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Pittsfield, Massachusetts	123	983				Elevation of water-surface, by Boston and Albany Railroad profile.
			361	50.5	7.15	
Ashley Falls, Massachusetts	81½	705				Elevation of rails at Housatonic Railroad crossing.
Falls Village, Connecticut	72½	622				Elevation of water-surface immediately below Housatonic Railroad Company's dam, as given in *Report of the Department of Public Works of New York City*, June 30, 1879. About 100 feet of the total fall of 165 feet occurs at Falls Village within a short distance.
			165	8.5	19.41	
1.8 mile above Cornwall Bridge	64	457				Elevation of water-surface as given in above report, page 71.
			352	34.5	10.20	
Mouth of Shepaug river	29½	105				Elevation of water-surface, as given by E. B. McNeill, civil engineer.
			105	18.5	5.68	
Birmingham	11	....				Tide-water extends to Birmingham. As stated by Col. J. W. Barlow, corps of engineers, U. S. army, the mean rise and fall of tide at the mouth of the river (Stratford) is 5.2 feet, and at Derby 4.7 feet.

Measurements have several times been made of the volume of the river in low stages, with the following results:

During the development of the Birmingham power, measurements were carried on which served as a basis for the assumption still made, that the stream can be relied upon there in the lowest stage for an average discharge during the 24 hours of 500 cubic feet per second.

During the summer of 1878 the river was carefully examined in connection with a scheme for diverting its waters for the supply of the city of New York.(*a*) The flow was gauged at Kent by Mr. Horace Loomis, assistant engineer, from May 22 to November 1. The results showed a minimum flow, during the period of gaugings, of 260 cubic feet per second, average for the 24 hours; and a mean flow for the entire season (May 22–November 1) of 460 cubic feet per second, average for the 24 hours.

a See *Report of the Department of Public Works of New York City* for the quarter ending June 30, 1879.

During the years 1881–'82 occasional observations were made of the flow at New Milford Falls by Mr. B. H. Hull, civil engineer, of Bridgeport. These measurements were rather roughly made, with a view to finding the minimum flow available during working hours, and gave the minimum for the period stated of 916 cubic feet per second.

The results of these various gaugings may be thus presented:

Gaugings of the Housatonic river.

Locality.	Drainage area.	Flow per second.	Cubic feet per second per square mile.	Remarks.	
	Sq. miles.	*Cubic feet.*			
Birmingham	1,562	500	0.32	Flow stated is the average for the 24 hours. Measurements made about 1867–'70, and result assumed as available amount of permanent water.	
Kent	758	260	0.34	Minimum	The volumes here stated are the average for the 24 hours. The measurements were made in the summer and fall of 1878 by Horace Loomis, assistant engineer of the board of public works, New York city.
Do	758	460	0.61	Mean for period May 22 to November 1.	
New Milford Falls	1,068	916	0.86	Minimum flow during working hours, as roughly measured by B. H. Hull. Average flow for the 24 hours would be much less.	

The Housatonic runs through a beautiful valley flanked much of the way by wooded hills, and with now and then a bordering of alluvial meadow-land. Its width increases from about 100 feet in the vicinity of Lee to 200 feet at Kent and to 500 or 600 feet at Birmingham. In the vicinity of Sheffield, in southern Berkshire county, the bed and banks are alluvial; at other points the material is gravelly, especially on the shoals, and at still others the stream falls over ledges of limestone and granite. Marble is quarried to some extent in the valley, and when free from flint is said to work well for building-purposes. A good quality of iron ore is found along the Housatonic, and is mined at Kent, Lime Rock, and in southern Massachusetts. Very pure quartz sand, suited to glass-making, also occurs.

The country drained by the river is quite thickly settled, the average number of inhabitants to the square mile, as stated by Mr. Henry Gannett, geographer of the Census Office, being 78, as against 57 for the Connecticut and 93 for the Merrimack basins. Especially in southwestern Connecticut and in western Massachusetts the varied and numerous manufacturing industries which have already been developed have attracted a large population of working people skilled in diverse pursuits—an important circumstance in connection with the further improvement of the Housatonic.

The valley has good railroad communications. The river is followed most of the way from the mouth to Pittsfield, in the upper waters, by the Housatonic railroad; it is crossed at the mouth by the New York, New Haven, and Hartford line, giving connections for New York and Boston; at Bennett's Bridge by the New York and New England railroad, running from Boston to Fishkill on the Hudson; at Shepaug by the Shepaug railroad; at North Canaan by the Hartford and Connecticut Western, reaching the Hudson river at Rhinebeck; and at Pittsfield by the Boston and Albany railroad. The distances by rail from tide-water, and from New York city, of some of the more important points along the river, are given below:

Distances by rail from tide-water of points on the Housatonic river.

Locality.	To Bridgeport.	To New York.
	Miles.	*Miles.*
Pittsfield, (*a*) Massachusetts	110	166
Stockbridge, Massachusetts	93	149
Falls Village, Connecticut	67	123
Cornwall Bridge, Connecticut	57	113
Bull's Bridge, (*b*) Connecticut	45	101
New Milford falls, Connecticut	32½	88½
Birmingham, Connecticut	(*c*)	69

a 51 miles from Albany. *b* Not now on railroad; would require a branch 2 or 3 miles long. *c* Located at head of tide-water in Housatonic.

Although a number of other interests are represented, especially at Birmingham, the great manufacturing industries of the main river are the production of paper and of woolen goods. Quite in contrast is the principal tributary, the Naugatuck, on which the chief use of power is in metal-working establishments. The development of power on the Housatonic has taken place mainly in the upper course, where the river is more easily and cheaply controlled than below, while numerous privileges available in the lower course have remained unimproved, or at least substantially so. Among the localities especially to be noticed in the latter respect are the interval of river between Birmingham and Bennett's Bridge, the falls at Bull's Bridge, and those at Falls Village.

Anchor-ice causes some hinderance to the mills on the upper river, though none of importance is experienced from floating cake-ice. Farther down stream, where there are fewer dams, surface-ice seems to be more troublesome, and the dam at West Cornwall is sometimes badly raked by it. On the Smith Paper Company's dams at Lee and Lenox, from 125 to 150 feet long, the common spring-freshet rise does not exceed about 5 feet; on the Ousatonic dam at Birmingham, with an overflow 636 feet long, the ordinary depth in a spring rise is estimated to be within the same limit. In 1874 a depth of 7 feet 9 inches on the dam was reached, and the next greatest depth observed was 6 feet 7 inches, in September, 1882. Freshets in the river run out quickly, and give rise to but little difficulty from backwater.

Judging by the results of gaugings, the yield of the Housatonic water-shed appears to be less per square mile, in very dry seasons, than in the case of either the Connecticut, Shetucket, or Quinebaug, to the eastward. Nevertheless, the volume is in general tolerably well sustained by a large number of ponds and reservoirs. It is almost impossible to obtain accurate data regarding these, but, using the best information at command, it is estimated that the total area of ponds and reservoirs within the Housatonic basin, making no account of the mill-ponds formed by the dams along the principal streams, amounts to at least 9,000 or 10,000 acres. Much has been done to improve the storage of the natural ponds by raising their surfaces by dams, and some entirely artificial reservoirs have also been built; undoubtedly the work might be carried on further on some of the tributaries, but it is the opinion of good judges that the reservoir capacity of the upper river has been developed about as much as is really practicable.

List of the principal ponds and reservoirs in the basin of the Housatonic river.

Name of pond.	Locality (town).	Tributary above what important point.	Approximate area.	Outlet.
			Acres.	
Pontoosuc lake	Lanesborough, Massachusetts	Pittsfield	a 313	Housatonic river.
Onota lake	Pittsfield, Massachusetts	do	555	Do.
Richmond pond	Richmond, Massachusetts	Lee	178	Scott brook, to Housatonic river.
Laurel lake	Lee, Massachusetts	do	152	Brook running to Housatonic river.
Plunkett reservoir	Hinsdale, Massachusetts	do	96	Artificial reservoirs draining through East branch to main Housatonic river. Areas are as given by manufacturers controlling them.
Tracy reservoir	do	do	65	
Ashmere reservoir	do	do	310	
Windsor reservoir	Windsor, Massachusetts	do	96	
Lake Mahkenac	Stockbridge, Massachusetts	Stockbridge	250	Brook running to Housatonic river.
Goose pond	Lee, Massachusetts	do	225	Do.
Greenwater pond	Becket, Massachusetts	do	100	Do.
Winchel pond	Egremont, Massachusetts	Sheffield	140	Green river, to Housatonic.
Six-mile pond	Monterey, Massachusetts	Falls Village	344	Mill river, to Konkapot, to Housatonic.
Brewer pond	do	do	250	Do.
Plantain pond	Mount Washington, Massachusetts.	do	120	Brook running to Housatonic.
Three-mile lake	Sheffield, Massachusetts	do	104	Iron Works river, to Housatonic.
East pond	New Marlborough, Massachusetts.	do	104	Umpachina, to Konkapot, to Housatonic.
Washining lake	Salisbury, Connecticut	do	650	No outlet shown on map.
Washinee lake	do	do	400	Schenob brook, to Housatonic.
Wononscopomus lake	do	Cornwall Bridge	355	Brook running to Housatonic.
Lake in northwestern part	do	do	b 210	Do.
Do	do	do	b 225	Do.
Wanonpakok lake	do	New Milford	170	Brook running to Ten-Mile river, to Housatonic.
Mudge pond	Sharon, Connecticut	do	230	Do.
Spectacle ponds	Kent, Connecticut	do	245	West Aspetuck river, to Housatonic.
Waramaug lake	Warren and Washington, Connecticut.	do	745	Aspetuck river, to Housatonic.
Marshapooge pond	Goshen, Connecticut	Bennett's Bridge	180	Shepaug river, to Housatonic.
Bantam lake	Litchfield and Morris, Connecticut.	Birmingham	c 1,070	Bantam river, to Shepaug, to Housatonic.
Long Meadow pond	Morris and Bethlehem, Connecticut.	do	255	Bantam and Pomeraug, to Housatonic.
Quaspaug pond	Middlebury and Woodbury, Connecticut.	do	535	Eight-Mile brook, to Housatonic.
North pond	Goshen, Connecticut	Mouth of Housatonic	d 300	Naugatuck river, to Housatonic.
Park pond	Winchester, Connecticut	do	d 60	Brook running to Naugatuck, to Housatonic.
Lily Brook reservoir	Wolcott and Waterbury, Connecticut.	do	e 112	Mad river, to Naugatuck, to Housatonic.
Chestnut Hill reservoir			e 80	Do.
Cedar Swamp reservoir			e 80	Do.
Approximate total area of 35 ponds and reservoirs			9,304	

a Area also stated by manufacturer on outlet at 575 acres.
b Extent of area lying within Connecticut. Lake is on boundary between that state and New York.
c Area also given as 1,200 acres.
d Area as stated by manufacturer interested in reservoir.
e Artificial reservoir; area as given by officer of reservoir association.

NOTE.—The above list includes the principal ponds and reservoirs drained by the river in Massachusetts and Connecticut, but the areas cannot be depended upon as very accurately stated. Unless otherwise indicated the areas for Massachusetts are as given by H. F. Walling in *Report of Massachusetts State Board of Health*, 1873, and those for Connecticut are as measured by planimeter on Clark and Tackabury's map of Connecticut, published in 1859.

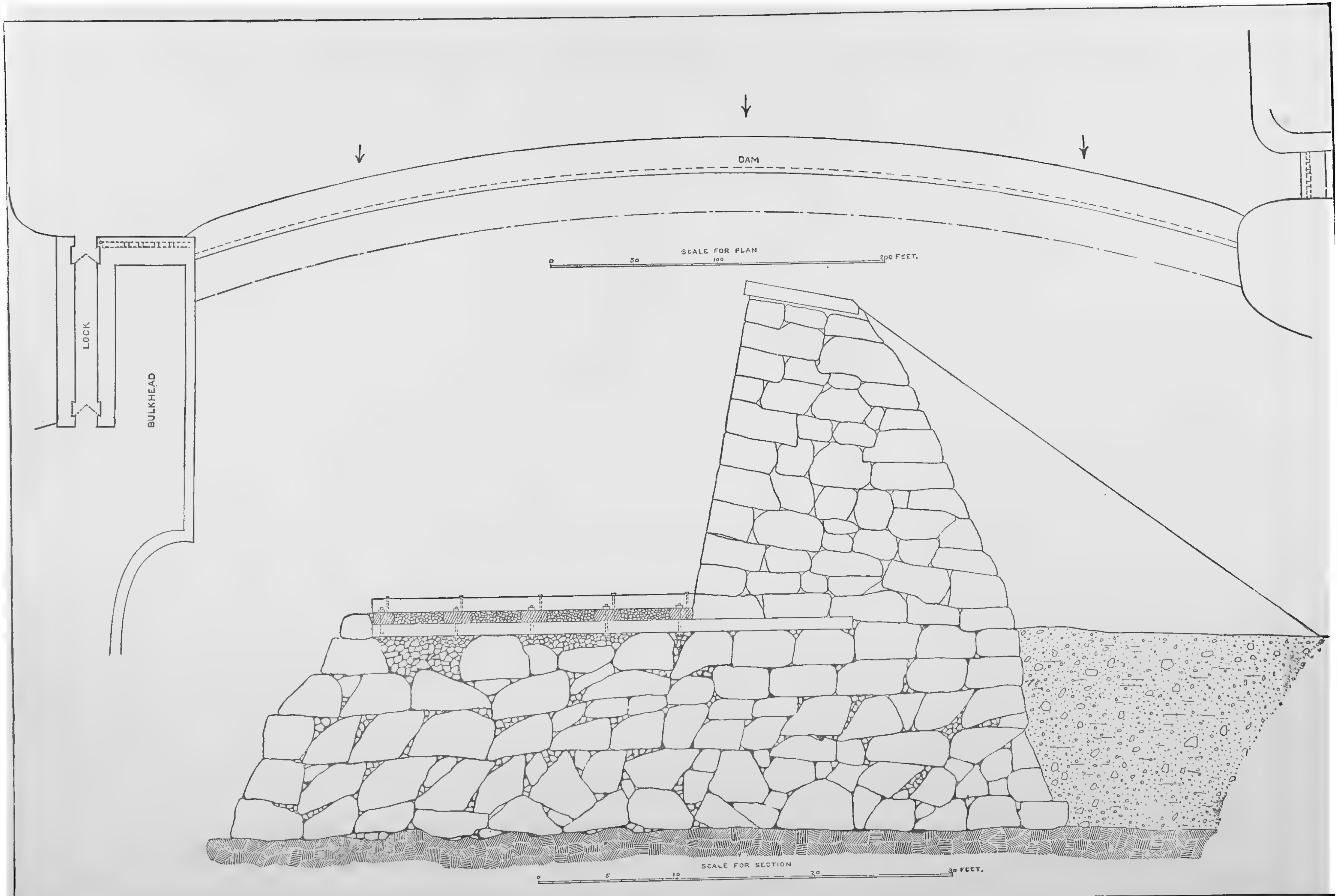

FIG. 29.—Plan and Section of Ousatonic Dam.

Power at Birmingham. (a)—The borough of Birmingham contains 3,000 inhabitants, and is located at the head of tide-water and navigation on the Housatonic, at the junction of that stream with its principal tributary, the Naugatuck. Vessels ascend the former river to the lower mills, and most of the heavy freighting is by water. At a reasonable expense it is stated that navigation can be extended up past half the length of the hydraulic canal. That canal is provided with a lift-lock from the river and a guard-lock to the pond above the dam, but passage through these is now confined to scows, which go a few miles up stream and bring down loads of timber, brick, and stone.

A plan of developing the water-power here was considered as long ago as 1838, and in the following year the state granted a charter for the purpose. Through fear of injuring the shad-fisheries, a high dam was not allowed, and the expense of bringing a long canal from a low dam was too great to be practicable, so that for many years nothing was done toward the actual improvement of the power. In 1864, however, permission was obtained to build a high dam; work was begun in July, 1867, and continued till October, 1870, when the dam was completed.

The privilege at Birmingham is unquestionably one of the best located and best developed in New England. It enjoys fine communications by land and water, and the natural site for canal and mills is excellent.

The dam is curving in plan, with a versed sine of 50 feet, and measures 636 feet in length between abutments. The width at base is 25 feet, the height from surface of apron to crest 22 feet, and the width of coping 8 feet. The structure is built of stone in cement, the face having a batter of about 2 inches in a foot. A timber apron, filled in with concrete, projects 24 feet from the front slope. The surface timbers of the apron are a foot square, and the bottom timbers extend some distance back under the stone-work of the dam. Where the latter rests upon gravel the apron has a pitch-plank, 7 feet long, supported at the end by a cross-timber 1 foot square. A row of sheet-piling extends under the down-stream edge of the apron and another under the face of the dam. The west abutment and the adjacent portion of the dam rest upon rock, while the remainder is founded upon gravel. In October, 1869, while the dam was in process of construction, and indeed nearly complete, a violent storm which swept over this part of the country caused a heavy freshet in the Housatonic; water poured 13 feet deep over the partially-finished dam, undermined and destroyed 160 feet of its length, and scoured out an immense cavity 20 feet deep in the river-bed immediately below. This space was afterward filled in with loose rock, the work on the dam was continued, and finally brought to an end in the following year.

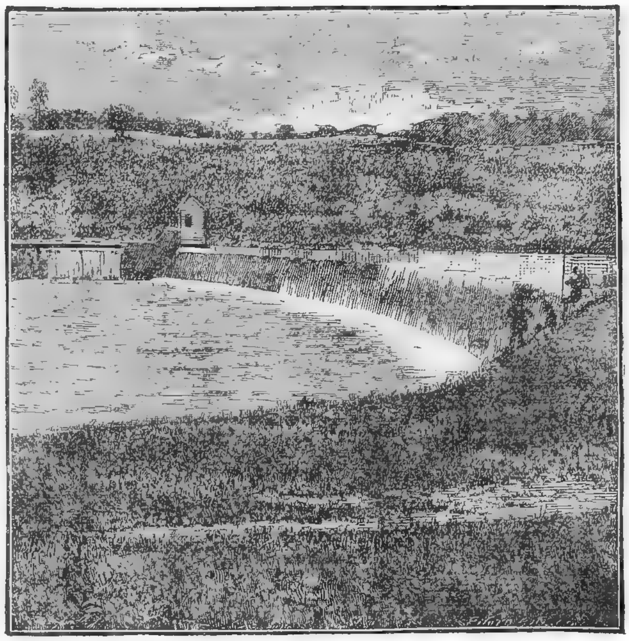

FIG. 28.—Ousatonic dam.

The abutments and bulkhead are also of masonry, in part coursed rubble and in part cut stone with rock face. The west bulkhead has 5 gate-openings, each 8 feet square; the east bulkhead has 3 gate-openings. The gates in the west bulkhead are operated by a turbine. Immediately adjacent the canal has a stone waste-weir 150 feet long. The dam sets back the water in the river some 5 miles up stream, thus affording a fine storage.

The west canal is 5,600 feet long, with a width at water-surface of 60 feet, and a depth below the same of 12 feet. For some distance from the dam it is restrained by an embankment on the river side; it then leaves the river somewhat and is carried partly as excavation along ground which has a gentle rise from the stream, leaving abundant and very favorable building-room between the two. The greater part of the way the canal is walled on both sides with dry stone. Nearly all the mills are upon the river side of the canal; one or two, however, are upon the opposite side and discharge tail-water into an arched passage-way running under the main canal. There is no other waste-weir than the one near the bulkhead, but a waste-gate in the lower course may be made to serve the same purpose, and gives opportunity for drawing off the water from the canal.

The cost of the works at Birmingham is stated as follows: Entire cost of dam, $264,000; locks, about $22,000; canal, $115,000; flowage and right of way, $17,000; an additional $12,000 for a break in the canal; making a total expenditure on account of hydraulic works of $430,000.

The concerns supplied with power are: 1. Wilkinson Brothers & Co., manufacturers of paper and wood-pulp; 2. Star Pin Company, hooks and eyes and hair-pins; 3. Spring Horse Shoe Company; 4. Wilcox & Howe, carriage hardware; 5. Robert Adams, cotton goods, mosquito-nettings, etc.; 6. D. M. Bassett, bolts; 7. Derby Silver Company, silver-plated flat and hollow ware; 8. Birmingham Corset Company; 9. Shelton Company, bolts and tacks; 10. Osborn & Cheesman Company, brass manufacturers; 11. Radcliffe Brothers, woolen goods; 12. E. C. Maltby, dippers and hollow ware; 13. Maltby, Stevens, & Curtis Company, flat plated ware; 14. New York Desiccating Company, desiccated cocoanuts; 15. A. B. Ruggles, toys.

a Mr. D. S. Brinsmade, secretary and treasurer of the Ousatonic Water Company, kindly furnished information concerning this power.

The Ousatonic Water Company owns the land and power, and leases the latter for terms of ninety-nine years. The usual policy of the company has been to donate the land for building-sites to desirable parties. The desire has been, not so much merely to lease all the power, as, for instance, to a few paper-mills, which use much water but do not employ a great many hands, as to secure a diversity of manufactures such as would serve to build up a large town.

The company does not guarantee water in any case, and if the flow of the stream should fall below the amount of permanent water leased, then all lessees of such water must share alike in a reduction. Three grades of water are recognized: First, permanent water, of which there are assumed to be 200 square feet (a square foot of water is declared in the leases to be 5 cubic feet per second, 12 hours in the day, 6 days in the week). As has before been mentioned, the flow of the river was gauged while the works at Birmingham were in progress, and the assumption here stated is based upon the results obtained at that time. The rental charged for permanent water is $250 per annum per square foot. Second, first surplus water, of which there are assumed to be 100 square feet. This can probably be relied upon for from ten to eleven months in the year, and is leased at the rate of $150 per annum per square foot. Third, second surplus water, of which also there are assumed to be 100 square feet, and which can be relied upon for much of the year, though the period varies considerably in different years. The rate for this class is $100 per annum per square foot.

Since land is commonly granted free at Birmingham, the rental charged there for water is a much better index of the real cost of the power to the manufacturer than at such a point as Holyoke, where the expenses for land and power are so combined as not to be easily separated. The Birmingham square foot, equal to 5 cubic feet of water per second, corresponds, under a fall of 22 feet, to almost exactly 12.5 theoretical horse-power. Assuming various degrees of efficiency in the turbines used, the equivalent effective powers, and their cost under the three classifications of water, are as follows:

Cost of water-power at Birmingham, on the Housatonic river.

Assumed efficiency of wheels.	Corresponding effective horse-power of 1 square foot of water.	COST PER EFFECTIVE HORSE-POWER.		
		Permanent water.	First surplus.	Second surplus.
60 per cent...	7.500	$33 33	$20 00	$13 33
65 per cent...	8.125	30 77	18 46	12 31
70 per cent...	8.750	28 57	17 14	11 43
75 per cent...	9.375	26 67	16 00	10 67
80 per cent...	10.000	25 00	15 00	10 00
85 per cent...	10.625	23 53	14 12	9 41

In case of a shortage of water the second surplus would be first curtailed, and then the first. If it became necessary to shut down on second surplus water, for instance, not all the lessees of that class of water would be equally curtailed at the same time, but in order as the water failed and according to the particular lease; generally speaking, the most recent lessee would be cut off first.

Up to October 13, 1882, 87½ square feet of permanent water had been leased and 14 square feet more had been contracted for; about one-half of the first surplus and 32 square feet of second surplus were also employed. About 183½ square feet of water will therefore soon be in use; but it is not to be inferred on that account that the available power is nearly exhausted, for that is not the case. The 183½ square feet include three grades of water, and from the company's stand-point the privilege is only about one-half disposed of, since there has been sold only one-half the permanent water. It is desired to sell the remaining half, and as it shall become necessary in pursuing that plan surplus water will be cut off so that the full amount of permanent water may be furnished to the lessees. The paper-mills are almost the only users of surplus water, and so long as the power has been but partially developed it has been for their interest to depend largely upon that class, which is much cheaper than permanent water.

The total amount of power in use here in the fall of 1882 was stated at about 1,500 horse-power by day and 500 by night. During the very dry summer of that year it became necessary to cut down slightly on surplus water, but it is claimed that with 2 feet of flash-boards on the dam there would have been no shortage. Flash-boards have not hitherto been employed, but the company purposes to use them in the future, if necessary. Except from August 21 to October 3 in the season alluded to, water wasted over the dam during the day—in other words, continuously; and in that interval it was with few exceptions running over in the morning, though not during the day. The pond is never drawn down more than 6 inches below the crest of the dam, the company having the right to curtail the use of water whenever that limit shall have been reached. There having been usually thus far an abundant supply, a very close watch has not been maintained upon the amounts of water in use. Whenever considered desirable, measurements have been made, always employing Francis' methods, with the use of either floats or weirs.

The fall from the water-surface in the canal at the mills, assumed to be at the same level as the crest of the dam, to average tide-water in the river is 22 feet. The fall varies slightly along the canal, but not to exceed 1 foot. It also fluctuates a little with the tide, the average rise and fall of which opposite the canal is given as from 2 to 3

feet. The duration of high-tide here, however, is said to be much shorter than at the mouth of the river. During freshets there is, of course, backwater in the river, but it lasts not more than a day or two so as to be a serious hinderance, the river quickly running out. Observation has shown that for every foot of rise on the dam there is a rise of about 2 feet in the river along the line of the canal. As before mentioned, the usual spring-freshet depth on the dam is not over 5 feet, and since its completion the depth has not exceeded 7 feet 9 inches.

The building of mills can be continued on either side of the river. The west canal will not be extended any farther, but not much over one-half the sites along its course are yet occupied. At any time when a demand for sites on the east side shall arise, the water-power company is prepared to use the canal on that side, which is already built and walled and connected with the pond by a substantial bulkhead with gates. This canal is designed to have a length of 1,500 feet, and will afford good building-sites along its entire course.

The available power at this privilege may be estimated as follows:

Estimated power of the Housatonic river at Birmingham.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*22 feet fall.*	
Low water, dry year	11	13½	13½	10	48	1,562	550	62.5	1,375	In the fall of 1882 stated at about 1,500 by day and 500 by night.
Low water, average year							690	78.4	1,725	
Available 10 months, average year							960	109.1	2,400	

The river above Birmingham.—From Birmingham backwater to Bennett's Bridge the Housatonic is almost a continuous rapid, with only short stretches of smooth water. The bed is gravelly, and the banks are firm and of good height, with no meadow-land until within half a mile or so of the bridge. This section of the stream is at present without railroad facilities, though a line is projected to follow up the west bank. It is considered that two good privileges might be developed here, with a fall of 15 or 20 feet each. According to the elevations previously given there is a fall of about 83 feet from the mouth of the Shepaug to the top of the Ousatonic dam, a distance of say 17 miles; what amount of this fall is actually available for power can be determined only by careful examination. There would be little difficulty in finding good sites for dams, but this part of the valley has the objection of being rather narrow and not favorable to the location of large villages.

At Bennett's Bridge an island divides the stream into two channels, one 180 and one 75 feet wide. For perhaps 2 miles above this point the stream is almost free from rapids, there being but one or two short ones. The valley is more open than below, the banks are frequently sandy, and are succeeded away from the stream by narrow meadows. Still farther up stream shoals become more frequent, but the banks are yet sandy in places, though generally of good height.

At Little York, a settlement of a few houses about 1 mile below Shepaug, a rude obstruction of stones has been thrown across the river, and turns water into a race a few hundred feet long. A small power is used here for a saw-mill and a cider-mill.

At Southville (Hawley's Bridge) there still remains part of a low dam, where power was used to some extent a number of years ago.

At Lanesville (New Milford Falls), about 26 miles by river above Birmingham, a fine power has been developed by the Bridgeport Wood Finishing Company. With the exception of a short piece next the west bank the dam is entirely a natural ledge of slaty rock. A large amount of rock excavation has been done, both for the wheels and on the site of the mill. Operations were begun in the summer or fall of 1881, and in the succeeding year 400 or 500 pounds of dynamite were used for blasting. The wheel-pit is sunk 20 feet into solid rock, and the head-race is cut out into the river sufficiently to thoroughly divert the low-water flow to the wheels. The fall obtained is 12 feet, and power is to be taken from two turbines, each of 250 horse-power. The works of the company, hitherto maintained at Fort Ann, New York, are to be removed to this point. Silica is conveniently obtained at various localities within a few miles of the mill, and will there be ground up into a very fine powder employed in giving a fine finish to wood and for other purposes. It is largely used by the Wheeler & Wilson Sewing Machine Company.

This privilege is located at the head of a narrow gorge, through which the stream tumbles down with rapid fall. There is no opportunity, however, for utilizing this larger descent by any ordinary means, either in the gorge or for some distance below; in the narrows the stream is entirely out of reach, and upon issuing from them it immediately spreads out into a wide and long pool.

Above this point the valley assumes an entirely new appearance; the hills recede on either hand and inclose fine level meadows; the stream is now quite free from shoals, and runs smoothly between alluvial banks of sandy loam.

Between the falls and New Milford village, and about a mile below the latter, James A. Giddings, jr., uses 150 horse-power for a grist-mill. He has a fall of 7 feet, which he states can be increased to 10 feet.

Estimate of power at Giddings' mill.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*	*10 feet fall.*	
Low water, dry year	1,068	380	43.2	300	430	150
Low water, average year		480	54.5	380	540	
Available 10 months, average year		670	76.1	530	760	

At Gaylordsville, a small village 2½ miles south of South Kent, rapids extend along the stream for 600 or 800 feet. The river is 150 or 175 feet wide; the banks are of good height, and on the west side, below the highway bridge, there is a convenient flat for building. The privilege seems to be a good one, and was formerly used by a grist- and saw-mill.

At Bull's Bridge, about 2 miles west of South Kent, there is a large undeveloped power. It is not upon any railroad, but it is said that a spur of 2 or 3 miles, to connect it with the Housatonic line, could be built without difficulty. There is a collection of a few houses near by, but no village of consequence. The falls here were probably once nearly or quite continuous, but a dam formerly in use sets back the river so as to cause slack-water for a little distance, and divides the falls into what may be called the upper and lower.

At the head of the lower falls is the old dam, a log structure, now broken and in poor condition. Rapids extend several hundred feet down stream, and the pocket-level indicates a fall of 16 or 18 feet from the crest of the dam to their foot. The banks are steep and rocky on each side. Twelve feet fall was once used here at an iron furnace on the left bank a couple of hundred feet below the dam. Water was conveyed in a wooden flume laid in an open way, inclosed on one side by the rocky bank and on the other by a dry-stone wall; both flume and wall are partly in ruins. This lower privilege is said to be owned by John Bogart, esq., of Lee, Massachusetts.

The upper falls are but a short distance above the dam. They are apparently about 400 feet in length, with a descent, as shown by the pocket-level, of say 22 feet. At an ordinary stage the river-bed displays a great mass of granite, down which the stream rushes in a channel-way perhaps 50 or 75 feet wide, though from one high bank to the other the width is much greater. Here, as at the lower falls, the banks are steep and rocky.

The entire fall at Bull's Bridge from the head of the upper falls to the foot of the lower privilege is probably about 40 feet, and this might be considerably increased artificially by a dam at the head. The site for such a structure is good, the ledges in the stream almost forming a natural dam. In the examinations made in 1878 to determine the practicability of drawing upon the Housatonic river for the water-supply of New York city, the privilege at Bull's Bridge was considered among the various points available for the purpose; but on account of the expense which the selection of this site would involve in pumping water to a height of over 100 feet in order to convey it over into the Croton valley, it was rejected. On page 72 of the report previously mentioned by title, the fall available at Bull's Bridge is referred to as 45 feet, though the height of dam necessary to give that fall is not stated. The entire fall here might be combined in one privilege or divided into two powers. In any case considerable blasting would be found necessary and the expense of improvement would be large. The adjoining land on either side of the river is hilly, but offers a fair location for mills on the right bank.

Estimate of power at Bull's Bridge.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.				
	Spring.	Summer.	Autumn.	Winter.	Year.							
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*12 feet fall.*	*40 feet fall.*	*45 feet fall.*	*50 feet fall.*
Low water, dry year	10½	13½	14½	10	48½	*a* 792	280	31.81	380	1,270	1,430	1,590
Low water, average year							350	39.76	480	1,590	1,790	1,990
Available 10 months, average year							490	55.66	670	2,230	2,500	2,780

a Above Ten-Mile river.

It may be said in general of the interval between New Milford and Kent, that the stream has a gravelly bed with banks usually firm and of good height. There is a succession of shoals and long stretches of smooth water, and numerous sites are to be found where a dam could be built to good advantage. The valley is of moderate width, and is succeeded by a hilly country tolerably well wooded with a young growth. The larger timber has been mainly cut away to supply charcoal to the iron furnaces, and in many places the hills are quite bare.

About half a mile above the village of Kent the Kent Iron Company has a furnace giving employment to 20 men. A log dam resting partly upon rock and partly upon gravel crosses the river in an irregular line. Water is conveyed 200 or 300 feet in a race and a wooden flume, and power is used for two blowers, a pump, and a 4-run grist-mill; 8 feet fall and perhaps 90 horse-power are in use, with surplus water at all times.

From Kent to Cornwall Bridge, about 8 miles, the general features of the river remain substantially unchanged. At Swift's Bridge a mile or more below Cornwall Bridge, power was formerly used for over 20 years by a grist-mill. The dam was located half a mile up stream and water brought down the right bank in a race, which remains in good condition, except that it is overgrown with brush. At the site of the old dam the river is 200 feet or more in width, and is said to have a bed of solid rock most of the way across. The structure was built of logs with stone abutments, but has entirely gone to ruin, only a few logs and scattered stones remaining. At the foot of the race a fall of 12 or 15 feet is available. The privilege is owned by Mr. Edward Bierce, of Cornwall Bridge.

Estimate of power at Swift's Bridge.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	12 *feet fall.*	15 *feet fall.*
Low water, dry year	735	260	29.5	350	440
Low water, average year		330	37.5	450	560
Available 10 months, average year		460	52.3	630	780

Just above the railroad station at Cornwall Bridge another privilege was formerly occupied by a grist-mill, but all signs of the improvements have vanished. There is a good site for a dam, with rock bottom two-thirds of the way across and gravel the remainder. The Housatonic railroad skirts the bank a short distance above the rapids, at an elevation of 11 or 12 feet from low water. On account of danger of flooding the tracks in high water it would not answer to build a dam more than a few feet high, unless it were given an unusually long overflow. With a dam as high as 6 or 7 feet and a race 300 feet long, from 10 to 12 feet fall could be made available. Mr. Benjamin F. Bierce, of Cornwall Bridge, owns this privilege, including right of flowage and right of way for a canal 300 feet long. The power is a good one, and has the advantage of a very convenient building-site.

Estimate of power at Cornwall Bridge.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*	12 *feet fall.*
Low water, dry year	724	260	29.5	290	350
Low water, average year		320	36.4	360	440
Available 10 months, average year		450	51.1	510	610

There is no power in use above Cornwall Bridge until we reach West Cornwall, where Messrs. Mallinson and Wood own 13 feet fall. The privilege is improved by a log crib-work dam filled in with stone; the dam averages about 8 feet in height, and has a sloping face, with an apron covered with 3-inch planking. The race is several hundred feet long, from 12 to 14 feet wide, and from 6 to 8 feet deep. Joseph Mallinson uses power for the manufacture of shears and scissors and for a grist-mill, and rents some power to a foundery. He has a 60 horse-power wheel, but does not use more than two-thirds of its power.

The next power to be noticed is at Falls Village, where there is a greater concentrated fall than is to be found upon any other stream of equal size tributary to Long Island sound. The Housatonic there falls abruptly over limestone ledges, and has a total descent of over 100 feet in a short distance. A little way above the head of the falls the Housatonic Railroad Company uses about 180 horse-power and from 11 to 13 feet fall in its shops, its privilege being improved by a dam.

The main privilege embraces a fall, as nearly as could be ascertained, of 95 feet,(*a*) and was partially developed about the year 1850 by the Falls Village Water Power Company. From the head of the falls a canal was carried approximately half a mile, with a width of 35 feet and a depth of 6 or 8 feet. It runs close by the railroad track, on a side-hill, its outer bank being supported by a fine masonry retaining-wall. At the end of this upper level is a bulkhead, through which water may escape down a steeply-inclined channel paved with stone and cement to the second or middle level, which is perhaps a quarter of a mile long and of the same cross-section as the upper level. From the second canal there is an escape to the third level. On the course of the latter was designed, in a natural depression, a large reservoir, from at least two points of which water was to be carried off in canals for use. After extending these canals for a short distance from the reservoir, work ceased. It is said that a stop was put to operations by dissensions in the company, and a magnificent power has continued to remain idle. It certainly seems a great misfortune that private disagreements should have prevented the full development and use of so fine a privilege. It would be an easy matter to divert water into the upper level, a low dam running

a See page 76, *Report of the Department of Public Works of New York City* for the quarter ending June 30, 1879.

across on a ledge being sufficient for the purpose. It is said that this upper canal leaked more or less when filled. It appears to be in good condition, but the bulkheads on this and the second level were constructed of large blocks of stone supported by timber, and would need to be rebuilt for use, the timber having decayed.

Estimate of undeveloped power at Falls Village.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*95 feet fall.*
Low water, dry year	10½	13½	14½	10	48½	644	250	28.40	2,70[illegible]
Low water, average year							310	35.22	3,35[illegible]
Available 10 months, average year							420	47.71	4,530

Above Falls Village the stream becomes more flat, and continues so through the town of Sheffield, in Massachusetts. At Great Barrington we strike upon the principal manufacturing portion of the Housatonic valley, and thence to the extreme head-waters there is a quick succession of busy little villages, the most important productions in which are paper and woolen goods. On the east branch, in the town of Dalton, George T. Plunkett, esq., of Hinsdale, owns 100 feet of unimproved fall; but on the main river between Falls Village and Pittsfield only one available unoccupied fall was reported, though it is possible there is some other fall entirely unimproved. The privilege referred to is owned by Captain Seeley, of Housatonic, and is the one formerly occupied by the Stockbridge Iron Works. The available head is 23 feet, the power corresponding to which may be estimated as follows:

Estimate of power at the Stockbridge Iron Works privilege.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*23 feet fall.*
Low water, dry year	12	14	16	10	52	284	130	14.8	340
Low water, average year							160	18.2	420
Available 10 months, average year							210	23.9	550

In the following table are given a list of the principal water-privileges on the Housatonic river below Pittsfield, and a summary of power available at the various unimproved falls, so far as could be learned of them. It is not to be supposed that all the available fall is here accounted for. But few reliable elevations on the river could be obtained from which to determine the intervening fall, and there are some portions of its course in which the descent is comparatively uniform, and where the head to be obtained is mainly determined by the height of dam. In some such cases estimates of power are given corresponding to one foot of fall:

Principal water-privileges on the Housatonic river below Pittsfield.

Locality.	Drainage area.	Firm.	Manufacture.	Fall.	Estimated theoretical horse-power. (a)			Remarks.
					Low water, dry year.	Low water, average year.	Available 10 months, average year.	
	Square miles.			*Feet.*				
Lenox		Smith Paper Company	Paper	10				The various privileges owned by the Smith Paper Company are improved by wooden dams built at various times in the past sixty years, and ranging from say 125 to 150 feet in length and from 4 to 15 feet in height. The aggregate horse-power of wheels at all the privileges was stated in 1880 to be about 1,480.
Do		do	do	10				
Lee		do	do	12				
Do		do	do	15				
Do		do	do	10				
Do		do	do	9				
South Lee		Hurlbut Paper Company.	do	19				Stone dam, built in 1873, cost $6,000; from 300 to 400 horse-power of water used.
Stockbridge	284	Privilege owned by Captain Seeley, of Housatonic.	Unoccupied	23	340	420	550	Formerly occupied by the Stockbridge Iron Works.
Glendale		Chapin & Callender	Paper (?)	20				Use 200 horse-power, and can run at full capacity throughout the year. Have large surplus power.
Do		Adams Mill	Woolen goods	10				300 horse-power used.

a Based upon average flow for the 24 hours.

Principal water-privileges on the Housatonic river below Pittsfield—Continued.

Locality.	Drainage area.	Firm.	Manufacture.	Fall.	ESTIMATED THEORETICAL HORSE-POWER. (a)			Remarks.
					Low water, dry year.	Low water, average year.	Available 10 months, average year.	
	Square miles.			*Feet.*				
Housatonic		Monument Mills	Cotton goods	16				176 horse-power used. Old dam built in 1760, 144 feet long, 16 feet high.
Do		do	do	8–10				88 horse-power used.
Do		Owen Paper Company	Paper	15				80 horse-power used.
Great Barrington		Berkshire Woolen Company.	Woolen goods	11				250 horse-power of wheels in 1880.
Falls Village		Housatonic Railroad Company.	Power used at shops.	11–13				180 horse-power of wheels in 1880.
Do	644	Privilege partially developed by Falls Village Water Power Company.	Unoccupied	95	2,700	3,350	4,530	A splendid power.
West Cornwall		Jos. Mallinson	Shears and scissors. Power also used for grist-mill and foundery.	13				Not over 40 horse-power used.
Cornwall Bridge	724	Privilege owned by Benjamin F. Bierce.	Unimproved	10–12	290–350	360–440	510–610	Good building-site in village close by railroad.
Swift's Bridge	735	Privilege owned by Edward Bierce, of Cornwall Bridge.	do	12–15	350–440	450–560	630–780	Formerly used for twenty years by grist-mill. Good site for dam. Old race remains.
Kent		Kent Iron Company	Power used for furnace and grist-mill.	8				Perhaps 90 horse-power in use.
Bull's Bridge	792	Said to be owned in part by John Bogart, of Lee, Massachusetts.	Unimproved	40–50	1,270–1,590	1,590–1,990	2,230–2,780	Fine privilege; 12 feet fall formerly used by iron works.
Gaylordsville	971	Privilege owned by various parties.	do	10	390	490	680	10 feet fall said to be available. Dam would need to be 230 feet long.
One mile below New Milford.	1,068	J. A. Giddings, jr	Power used for grist-mill.	7–10	300–430	380–540	530–760	Owner would sell at satisfactory price. About 150 horse-power used.
Lanesville (New Milford Falls).		Bridgeport Wood Finishing Company.	Grinds silica	12				Power recently developed. 500 horse-power to be used.
Southville	1,202		Unimproved		b48.8	b60.2	b85.2	Power formerly used.
Little York	1,371		Small power used for saw-mill and cider-mill.		b54.5	b68.2	b96.6	Small settlement.
Bennett's Bridge to Birmingham.	1,496–1,562		Unimproved		b60	b75	b105	Estimated that two good powers can be developed with from 15 to 20 feet fall each.
Birmingham	1,562	Power owned by Ousatonic Water Company.	See description	22	1,375	1,725	2,400	Located at tide-water.

a Based upon average flow for the 24 hours. b Per foot fall.

TRIBUTARIES OF THE HOUSATONIC RIVER.

THE NAUGATUCK RIVER.

This is the largest tributary of the Housatonic, and has a drainage-area of 313 square miles. It heads in the towns of Goshen and Norfolk, Litchfield county, Connecticut, runs southerly and joins the main river on the east side at Birmingham, having a length by general course of about 35 miles. It is followed closely from the mouth to Wolcottville, well up toward the head-waters, by the Naugatuck railroad, and is crossed at Waterbury by the main line of the New York and New England railroad. From the best information to be obtained the fall from Waterbury to mean tide at Birmingham, a distance of about 18 miles by river, appears to be something over 230 feet,(a) or an average of about 13 feet per mile.

The Naugatuck was examined from the mouth to Waterbury. It can have but moderate value for power above that point; in fact, it is there joined by Mad river, which is regarded as more important than the main stream above their junction, although its drainage area is much smaller. This probable disparity in value is due to the two facts that Mad river has a more rapid fall than the Naugatuck and that it is better sustained in the dry season. Both streams are moderately supplied with storage reservoirs. The former has three principal reservoirs controlled by the Mad River Water Power Company: Lily Brook reservoir, of 112 acres; Chestnut Hill reservoir, 80 acres, and Cedar Swamp reservoir, 80 acres. On the upper waters of the Naugatuck are North pond, in Goshen, said to contain from 300 to 350 acres, from which about 6 feet can be drawn, and Park pond, in Winchester, of 60 acres, from which an average of 10 feet can be drawn. The subject of further reservoiring the stream has been

a Mr. W. G. Smith, formerly resident engineer of the New York and New England railroad, gives the elevation of the Naugatuck river at Waterbury as 242 feet above low water in Boston harbor.

discussed, but no action has yet been taken. It is said that there are no natural ponds or marshes of large size which could be improved for storage, and it is the opinion of prominent manufacturers that the expense of reservoirs under the circumstances would be out of proportion to the benefits to be derived.

Throughout the section examined the river has a gravelly bed, over which it runs in shoals and rapids, except where interrupted by slack-water from the dams. The valley is narrow and inclosed by high hills, which are in many places rocky, steep, and even precipitous. So far as was noticed one bank or the other of the stream is usually low. The character of the country drained is such that the river is rapid in rise and fall and its freshets are heavy. At Seymour it is said to continue rising about 6 hours after a rain has ceased, and then to begin receding. In the heavy storm of September, 1882, it rose at the rate of about a foot an hour, and fell away again with nearly the same rapidity.

The dams on the Naugatuck are nearly all low structures, the falls in use being largely gained by long races; they are mostly old, and no other explanation of their having been built low was received than that the river is one requiring strong works, and high dams would have been more expensive. It would appear also that, from the common occurrence of a low bank for some distance back on one side or the other, higher dams would also have to be considerably longer than the present ones, and would be more costly on that account. The powers on this river were generally developed years ago, when the concerns using them were small; the latter have increased greatly in size, have in many cases outgrown the stream, and have been obliged to add steam-power. The use of long races increases the danger of trouble from ice, and it was said by an engineer well acquainted with the river, that they are in many instances too small to carry the required volume of water, so that when the wheels are being run at full capacity they are liable to be drawn down and the working head becomes reduced.

The first water-privilege above the mouth of the river is owned by the Birmingham Water Power Company. The dam is a rough timber structure, 7 feet high and perhaps 300 feet long. It extends in two rather irregular sections from either shore to an island in the center of the river. The only abutments are piles of loose bowlders. From the foot of the dam extends an apron of short lengths of logs, below which the river-bed is still further protected by a mass of loose stone. The dam is located in the lower part of the borough of Ansonia. Two races, soon uniting in a single line, convey water a little over a mile down the west bank to Birmingham, where power is used by the following principal concerns:

The Sterling Organ Company, manufacturer of cabinet organs; the Birmingham Bit Company; the Birmingham Iron Foundery; the Peck, Stowe, & Wilcox Company, rolling-mill and bolts; the Howe Pin Company; Summers & Lewis, furniture; H. S. Sawyer, feed-mill; R. M. Bassett, corset supplies; H. & C. B. Alling, woolen-mill.

The fall at the mills is about 12 feet, subject to some fluctuation from tide-water, which sets up to this privilege. The permanent flow of the river is assumed at 20 square feet, which is all leased, as well as 20 square feet of surplus water. According to the census enumerators' returns, the aggregate horse-power of wheels employed on the privilege in 1880 was 590. Water is regarded here as the principal power, although resort is made to steam for additional power in low water. The amount, 20 square feet, assumed as the permanent flow of the stream is said to be somewhat above the real low-water volume, and for from one to three weeks in the year is not realized.

The square foot, to which reference has been made, and the method of measuring it, are thus defined in the leases:

And the Birmingham standard square foot of water hereby leased shall consist of 144 square inches of aperture, and such aperture shall be of a parallelogram form, and situated in the tail-race conducting the water herein granted from the water-wheel where used, and the water drawn through said aperture under a head of 12 inches from the surface of the water to a line supposed to be drawn longitudinally through the middle of said aperture shall constitute the Birmingham standard square foot of water.

And the said one Birmingham standard square foot of surplus water hereby leased and the water drawn and used from said reservoir and canal by said ———, party of the second part, under other deeds or leases shall be measured in the manner following; to wit, a flume or trough shall be constructed in the tail-race through which the water used by said ———, party of the second part, shall be discharged, equal in width to the number of square feet of water that the said ——— or his assigns is or shall be entitled to draw from said reservoir or canal under a head of one foot, with vertical plank sides at least 18 inches in height and a smooth plank bottom, inclined in the direction of the descent of the tail-race at the rate of 1 inch in 6 feet. That at a point 18 inches up stream from the lower end of said flume, a square-edged plank 6 inches in width shall be placed vertically at right angles to the side of said flume and 1 foot above the bottom, forming thereby beneath the plank an aperture of a parallelogram form one foot in height by the width of the flume, or the length required under the head of 12 inches to measure the number of Birmingham standard square feet of water which said ——— is or shall be entitled to draw and use; the flume to extend up stream beyond the cross-plank a distance equal at least to once and one-half the width of the flume, and whenever the water discharged through the tail-race shall fill the aperture beneath the plank and the surface of the water shall be level with the top of the cross-plank, the water having a free flow from the end of the flume, then the quantity discharged will be the quantity that said ——— or assigns is or shall be entitled to draw.

Directions are then given in the leases for measuring fractional parts of the amount the lessee is entitled to draw; and for measuring the flow in the tail-race by another method.

The next use of power is at Ansonia, a borough of 3,900 inhabitants. The privilege is owned by the Ansonia Land & Water Power Company. The dam is above the village, and is built diagonally across the river in a somewhat irregular line between abutments of rubble masonry. It is a timber structure, with a sloping face planked and having projecting ribs. The bulkhead is of timber with masonry side walls, between which the width is about 20 feet. The canal runs down the east bank of the river to the village, where the mills are located; it is

some 2 miles long, varies from 50 to 100 feet in width most of the way, and from 5 to 7 feet in depth. In part of its course it widens out so that with the pondage above the dam there is an aggregate reservoir surface of probably 80 acres or more.

The entire "head and fall" on this privilege is about 33 feet. Water is drawn from the canal in flumes under a full head of 30 inches, a square foot of water under that head constituting the standard square foot here, and being estimated to produce 30 theoretical horse-power. The privilege is assumed to yield 20 square feet of permanent water and 30 of surplus. Permanent water is considered to be worth $600 per annum per square foot, and surplus water from $250 to $500 per annum per square foot. The leases are said to be loosely drawn so far as regards defining the amount of water that may be used, and accurate measurements are not attempted. The brass companies are the principal owners in the water-power company, and are said practically to manage the water as they please. It is even reported that one company has extended its flume out under and then up into the bottom of the canal.

The ordinary power of the privilege is fully in use; in fact, most of the concerns, being of large size, use steam as well as water, the former being probably the more important source of power here. By the enumerators' returns a total of 1,600 horse-power of wheels was in use in 1880. All the permanent water, and two-thirds of the surplus, have been leased, as follows:

Lessees of water at Ansonia.

Company.	Permanent water.	Surplus water.	Remarks.
	Square feet.	*Square feet.*	
The Ansonia Brass & Battery Company	13	10	Uses steam and water. Manufactures sheet-, bolt-, and ingot-copper, sheet brass, brass and copper wire, etc.
Wallace & Sons	3	3	Use more steam- than water-power. Manufacture sheet brass and brass goods.
The Osborn & Cheesman Company	2	2⅔	Uses both steam and water. Manufactures sheet brass and brass goods.
The Farrell Foundery & Machine Company	1	2	Uses both steam and water. Very extensive works.
The Slade Woolen Company	1	2	Not in operation.
J. B. Gardner		1	Manufactures clock-cases.
R. R. Colburn		1	
	20	21⅔	

At Seymour, the next manufacturing point, about 3 miles above Ansonia, there are two water-privileges on the Naugatuck. The lower is considered equal to about 20 square feet of permanent water, and is owned by the following concerns:

The J. H. Tingue Manufacturing Company, plush goods, 1 square foot; Carlos French, springs, 2 square feet; the United States Pin Company, 2 square feet; the Humphreysville Manufacturing Company, augers and bits, 3 square feet; the New Haven Copper Company, 12½ square feet.

The fall on the privilege is 18 feet. Sufficient water is obtained for the supply of the mills nine months in the year, but the stream runs very low in summer. No attempt is made to measure the water used For this power a great outcropping ledge forms a natural dam stretching half-way across the river. The rest of the way the dam is artificial, and is built of stone upon a rock foundation. This portion is about 175 feet long, and contains three arched openings with gates for drawing down the pond. A timber bulkhead admits water to a short race leading to the various mills.

The upper privilege is owned by the Rimmon Water Company and embraces 18 feet fall. The flow of the stream is nominally divided into twelfths and is sold at such prices as may be agreed upon, there being no fixed rate. All the permanent power has been disposed of. The dam is in two straight sections forming something more than a right angle, one section having a sloping face and the other a vertical one. It is a fine structure of stone, and is supplemented by an embankment, giving a total length of perhaps 1,250 feet, including the 250 feet of roll-way. The abutments are of rubble masonry, and rise 8 feet above the crest of the dam. Above the latter is a pondage of about 115 acres. A small race leads down the east bank to W. W. Smith's manila paper-mill, where 14 feet head and 90 horse-power are in use. In dry seasons this mill is short of water from six weeks to three months. The main race is on the west side of the river, and supplies the Seymour Manufacturing Company, manufacturer of brass and German silver and lessee of one-half the flow of the stream; also the Fowler Nail Company, manufacturer of horseshoe nails and lessee of one quarter the flow. In the summer of 1881 these concerns were somewhat short of water for about two weeks, but have not been troubled in that way at any other time. In 1880 a total of about 700 horse-power of water-wheels was in use at the two privileges here described.

At Beacon Falls the Home Woolen Company has been in operation about two years; it runs 18 sets of cards and employs 275 hands in the manufacture of fancy cassimeres. The dam is a low structure, presenting an angle up stream, and abutting against masonry at the east end and a natural ledge at the west. A long race leads perhaps half a mile down to the mill, where the fall is 22 feet. Since starting, the mill has always had sufficient water for running at full capacity.

Between Beacon Falls and the mouth of Beacon Hill brook, a distance of about a mile and a half, the valley of the Naugatuck is much of the way very narrow, being shut in by high hills with rocky precipitous slopes.

The fall is rapid over a gravelly bed. The railroad follows the west bank, and would probably be in danger of overflow if a high dam were built. Above Beacon Hill brook the valley is more open again, though its width is nowhere great. In the 3 miles between Beacon Falls and Naugatuck village it is probable that two fair powers might be developed.

The lower privilege at Naugatuck is owned by Lauren Ward, and occupied by L. & W. Ward in the manufacture of various small brass goods. The establishment is small, and but little power is used—as estimated, not over one-quarter the amount available. A low wooden dam, 180 or 190 feet long and 18 or 20 inches high, diverts water into a race leading to the shop, where it is used on an old-fashioned scroll-wheel running under a head of 5 feet.

It is said that a survey has shown the fall from the top of Ward's dam down to the mouth of Beacon Hill brook to be 16 feet, the power corresponding to which is estimated as below:

Estimated power between Naugatuck and Beacon Hill brook.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	(*a*) 5 *feet fall.*	16 *feet fall.*
Low water, dry year							70	8.0	40	130
Low water, average year	10½	13½	12	10	46	240	90	10.2	50	160
Available 10 months, average year							180	20.4	100	330

a A few horse-power already in use under this fall, as noticed above.

The upper privilege at Naugatuck is improved by a log dam 5 or 6 feet high, from which a race from one-third to one-half of a mile in length runs to the mills. The Goodyear's Rubber Manufacturing Company and the Goodyear's India Rubber Glove Manufacturing Company, practically one concern, have 12 feet fall and own 5 square feet of permanent water, the whole privilege being reckoned at 9 square feet; they also own all the surplus water. These concerns run two water-wheels, one of 80 and one of 40 horse-power, and have sufficient water for them about 8 months in the year. The remaining 4 square feet of permanent water is owned by the Tuttle Manufacturing Company, manufacturer mainly of hoes, rakes, and forks.

Between Naugatuck and Platt's mills there is some fall unimproved, probably enough at least for one good privilege.

Two-thirds of the next privilege is owned by the Platt Mills Company and the power used for a grist-mill; and one-third by Platt Brothers & Co., manufacturers of buttons. A timber dam with a stone apron runs in an irregular line across the stream, and a long race leads thence to the mills, where there is a fall of 17 feet.

Between Platt's mills and Waterbury there is one unimproved privilege (available fall said to be 14 feet), owned by the heirs of the late Merritt Nichols.

Estimate of power at the Nichols privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	14 *feet fall.*
Low water, dry year		60	6.8	100
Low water, average year	212	80	9.1	130
Available 10 months, average year		160	18.2	250

The next power is the lower one at Waterbury. It is situated above the mouth of Mad river, and is occupied by the extensive brass, German-silver, and copper rolling- and wire-mills of the Benedict & Burnham Manufacturing Company. This concern uses 8 feet fall and a 40 horse-power wheel, for which there is always water enough.

The upper privilege at Waterbury is occupied by the Waterbury Brass Company, manufacturers of brass, gilding-metal, copper, and German silver. Water-power is here used from both the Naugatuck and Mad rivers, and steam-power in addition. The dam on the Naugatuck is of crib-work filled with stone, 150 feet long and 5 feet high. Water is brought to the mill a mile and a half in a race, which enlarges at points so as to give in the aggregate considerable pondage. A fall of 16 feet is obtained, and power is taken from a 50 horse-power turbine and a 125 horse-power breast-wheel. Both wheels can be run for not over six months in the year, but there is always water enough for the turbine alone.

The principal powers above on the Naugatuck, so far as could be learned, are at Thomaston and Wolcottville. At the former point the Seth Thomas Clock Company has large works. At Wolcottville the Coe Brass Company has 27 feet fall and 150 horse-power. The dam at this privilege was built in 1866 and cost about $18,000; it is constructed of timber and stone and is 96 feet long and 18 feet high.

Mad river, the most important tributary of the Naugatuck, furnishes several valuable powers in the city of Waterbury, with large falls ranging from 28 to 42 feet. The principal users of power in 1880 were the Waterbury Brass Company, Rogers & Brother (cutlery), the Scoville Manufacturing Company, the American Suspender Company, and the Benedict & Burnham Manufacturing Company. The Scoville Company has 42 feet fall and 250 horse-power. The company estimates that the full amount can be realized four months in the year, one-half capacity for an additional four months, and for the remaining four months only about one-quarter capacity.

THE SHEPAUG RIVER.

This stream rises in the town of Goshen, Litchfield county, Connecticut, flows southerly through the county, and in the western part of the town of Southbury unites with the Housatonic. Its drainage basin includes 153 square miles. In the town of Washington there is received, from the east, Bantam river, a short stream heading in Bantam lake, which contains 1,000 or 1,200 acres. The Shepaug railroad runs up the valley of the main stream from its mouth, and then follows up Bantam river and passes on to Litchfield. The Shepaug river runs over a gravelly bed and between banks of moderate height. The fall is rapid both in this stream and in the Bantam river, but the supply of water seems to be small in the dry season, and the only use of power is by a few saw- and grist-mills and one or two shops.

Table showing the fall in the Bantam and Shepaug rivers.

Locality.	Distance from mouth.	Elevation above tide.	Fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Bantam lake	25½	888	401	25½	30.5	The elevations here given are furnished by Mr. E. B. McNeill, civil engineer, of Litchfield. He also states that at Bantam there is a fall of 108 feet in 3,500 feet.
Washington	16	482	172			
Roxbury	6½	310	205			
Mouth of Shepaug	0	105				

Table of power utilized on the Housatonic river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Housatonic river	Long Island sound.	Connecticut	Fairfield	Brass	1	Fall at mills, 22 feet.	....	....	Birmingham: Total horse-power of wheels in use in 1880, as returned by census enumerators and here detailed, 946. In the fall of 1882 the power in use was stated to be about 1,500 effective horse-power by day and 500 by night.
Do	do	do	do	Corsets	1		8	....	
Do	do	do	do	Cotton	1		250	....	
Do	do	do	do	Dippers and hollow-ware	1		....	....	
Do	do	do	do	Electro-plating	2		40+	....	
Do	do	do	do	Food preparations	1		4	....	
Do	do	do	do	Hardware, carriage	1		80	....	
Do	do	do	do	Horseshoes	1		....	....	
Do	do	do	do	House-furnishing goods	1		5	....	
Do	do	do	do	Iron nuts, bolts, washers, and rivets.	2		110	....	
Do	do	do	do	Needles and pins	1		30	....	
Do	do	do	do	Paper	1		300	....	
Do	do	do	do	Saw	1		35	....	
Do	do	do	do	Toys	1		....	....	
Do	do	do	do	Wood turning and carving.	1		4	....	
Do	do	do	do	Woolen	1		80	....	
Do	do	do	New Haven	Saw and cider	1	....	....	....	Little York.
Do	do	do	Litchfield	Flouring and grist	1	7	150	....	New Milford.
Do	do	do	do	Iron furnace	1	8	[illegible]	....	Kent.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Cutlery and edge-tools	1	13	60	....	West Cornwall.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Iron foundery	1				
Do	do	do	do	Machinery	1	11–13	180	....	Falls Village.
Do	do	Massachusetts	Berkshire	Blacksmithing	1	10	10	....	
Do	do	do	do	Cotton	2	16, 10	264	....	Monument Mills, Great Barrington.
Do	do	do	do	do	1	14	100	....	Pittsfield.
Do	do	do	do	Flouring and grist	6	103	281	20	
Do	do	do	do	Paper	15	233	2,920	1,694	

Table of power utilized on the Housatonic river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Housatonic river	Long Island sound	Massachusetts	Berkshire	Saw	8	121	235		
Do	do	do	do	Woolen	10	166	1,198	695	
Naugatuck river	Housatonic river	Connecticut	New Haven	Bolts	1	12	60		Birmingham: Total power in use in 1880, as here enumerated, 590 horse-power, water; 529 horse-power, steam.
Do	do	do	do	Corsets and supplies	2		22	75	
Do	do	do	do	Fancy articles	1		5	3	
Do	do	do	do	Flouring and grist	1		60		
Do	do	do	do	Furniture	1		20		
Do	do	do	do	Hosiery	1		90	80	
Do	do	do	do	Iron and steel	1		20	250	
Do	do	do	do	Machinery	1		150	80	
Do	do	do	do	Organs	1		60		
Do	do	do	do	Pins	1		36	24	
Do	do	do	do	Tools	2		20	7	
Do	do	do	do	Toys and games	2		39	10	
Do	do	do	do	Wood turning and carving	1		8		
Do	do	do	do	Brass and copper, rolled	3	Fall at mills, from 28 to 32 feet.	1,080+	1,662+	Ansonia: Total power in use in 1880, as here enumerated, 1,600 horse-power, water; 2,227 horse-power, steam.
Do	do	do	do	Clocks	1		40	30	
Do	do	do	do	Clock materials	1		30	30	
Do	do	do	do	Cotton	1		40	50	
Do	do	do	do	Hardware	1		5	5	
Do	do	do	do	Hosiery	1		60		
Do	do	do	do	Leather belting and hose (?)	1		25	25	
Do	do	do	do	Machinery	1		120	100	
Do	do	do	do	Wire	1		200	275	
Do	do	do	do	Brass and copper, rolled	2	Two privileges, each of 18 feet fall.	340	200	Seymour: Total water-power in use in 1880, as here enumerated, about 700 horse-power.
Do	do	do	do	Blacksmithing	1		5		
Do	do	do	do	Nails	1		100		
Do	do	do	do	Needles and pins	1		30		
Do	do	do	do	Paper	1		90		
Do	do	do	do	Plush	1				
Do	do	do	do	Springs	1				
Do	do	do	do	Tools	1		35		
Do	do	do	do	Vulcanized rubber (?)	1		100		
Do	do	do	do	Woolen	1	22			Beacon Falls.
Do	do	do	do	Small brass goods	1	5	7		Naugatuck.
Do	do	do	do	Rubber and elastic goods	1	12	120	120	Do.
Do	do	do	do	Agricultural implements	1		150	80	Do.
Do	do	do	do	Flouring and grist	1	17	145±		Platt's mills.
Do	do	do	do	Buttons	1				
Do	do	do	do	Brass and copper, rolled	*a* 1	8	40		
Do	do	do	Litchfield	Boxes, wooden packing	2	30	80		
Do	do	do	do	Brass and copper, rolled	1	27	150	400	Wolcottville.
Do	do	do	do	Carriage and wagon materials.	1	3	12		
Do	do	do	do	Clocks	1	11 22 24	107	185	Thomaston.
Do	do	do	do	Cutlery and edge-tools	1	8	18		
Do	do	do	do	Flouring and grist	3	60	65		
Do	do	do	do	Furniture	1	10	12		
Do	do	do	do	Hardware	1	22	50	40	
Do	do	do	do	Paper	1	10	50		
Do	do	do	do	Saw	10	144	263		Mainly in Harwinton and Torrington.
Do	do	do	do	Wheelwrighting	1	15	15		
Mad river	Naugatuck river	do	New Haven	Brass and copper, rolled	3	104	755	1,020	
Do	do	do	do	Brassware	1	30	60	40	
Do	do	do	do	Britannia and plated ware	1	20	80	150	
Do	do	do	do	Cutlery and edge-tools	1	28	55		
Do	do	do	do	Paper	2	111	110		
Do	do	do	do	Rubber and elastic goods	1	14	120	180	
Do	do	do	do	Tannery	1	13	40		
All other tributaries.	do	do	do	Brassware	1	40	40	75	
Do	do	do	do	Buttons	3	84	75	30	

a Another mill is supplied partly from the Naugatuck and partly from Mad river, having 16 feet fall on the former stream.

Table of power utilized on the Housatonic river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
All other tributaries.	Naugatuck river	Connecticut	New Haven	Carpentering	1	....	30	4	
Do	do	do	do	Carriage and wagon materials.	2	32½	25	40	
Do	do	do	do	Clocks	1	60	30	70	
Do	do	do	do	Cutlery and edge-tools	5	114	153	50	
Do	do	do	do	Electrical apparatus and supplies.	1	26	150	40	
Do	do	do	do	Fancy articles	2	37	21	....	
Do	do	do	do	Files	1	15	3	....	
Do	do	do	do	Flouring and grist	1	16	20	....	
Do	do	do	do	Hardware	2	46	20	12	
Do	do	do	do	Hosiery	2	53	50	110	
Do	do	do	do	Machinery	1	22	30	....	
Do	do	do	do	Needles and pins	2	82½	48	....	
Do	do	do	do	Paper	1	24	45	32	
Do	do	do	do	Rubber boots and shoes	1	57	400	350	
Do	do	do	do	Saw	4	53	68	....	
Do	do	do	do	Tools	2	32	116	30	
Do	do	do	do	Umbrellas and canes	1	14	8	....	
Do	do	do	do	Upholstering	1	15	10	....	
Do	do	do	do	Wood turning and carving	1	20	18	....	
Do	do	do	Litchfield	Carpentering	1	26	6	....	
Do	do	do	do	Cutlery and edge-tools	4	76	80	25	
Do	do	do	do	Flouring and grist	2	50	47	....	
Do	do	do	do	Hardware	2	33	24	....	
Do	do	do	do	Hooks and eyes	1	12, 16	75	40	
Do	do	do	do	Saw	3	78	87	....	
Do	do	do	do	Silk	1	10	25	30	
Do	do	do	do	Sporting goods	1	28	14	....	
Do	do	do	do	Umbrellas and canes	1	21	23	25	
Do	do	do	do	Wheelwrighting	1	30	27	13	
Do	do	do	do	Wood turning and carving	1	22	4	....	
Do	do	do	do	Woolen	1	12	80	80	
Pomperaug river and tributaries.	Housatonic river	do	New Haven	Flouring and grist	2	19	70	....	
Do	do	do	do	Saw	1	12	50	....	
Do	do	do	do	Woolen	1	16	18	....	
Do	do	do	Litchfield	Carriages and wagons	1	16	16	....	
Do	do	do	do	Flouring and grist	3	58	46	....	
Do	do	do	do	Paper	1	16	30	....	
Do	do	do	do	Saw	3	38	60	....	
Do	do	do	do	Sporting goods	1	14	15	....	
Do	do	do	do	Woolen	3	38	66	40	
Shepaug river and tributaries.	do	do	do	Carriages and wagons	2	27	44	....	
Do	do	do	do	Cutlery and edge-tools	1	16	25	....	
Do	do	do	do	Cigars	1	....	4	....	
Do	do	do	do	Cotton	1	18	51	....	
Do	do	do	do	Files	1	20	10	....	
Do	do	do	do	Flouring and grist	6	99	208	....	
Do	do	do	do	Iron castings	1	8	4	....	
Do	do	do	do	Kaolin and ground earths	1	18	12	....	
Do	do	do	do	Saw	6	92	347	....	
All other tributaries.	do	do	New Haven	Flouring and grist	1	7½	12	....	
Do	do	do	do	Sashes, doors, and blinds.	1	18	10	....	
Do	do	do	do	Saw	3	35+	65	....	
Do	do	do	do	Wood turning and carving	1	20	10	....	
Do	do	do	Fairfield	Belting and hose, rubber	1	41	500	250	
Do	do	do	do	Butter and cheese	1	10	10	10	
Do	do	do	do	Buttons	2	26	16	19	
Do	do	do	do	Carriage and wagon materials.	1	17	17	15	
Do	do	do	do	Churns	1	....	4	....	
Do	do	do	do	Combs	1	30	20	40	
Do	do	do	do	Cutlery and edge-tools	1	12	35	....	
Do	do	do	do	Flouring and grist	12	187	254	....	

Table of power utilized on the Housatonic river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
All other tributaries.	Housatonic river	Connecticut	Fairfield	Hardware	1	22	40	....	
Do	...do	...do	...do	Hat and cap materials	3	28+	87	120	
Do	...do	...do	...do	Paper	2	32	105	55	
Do	...do	...do	...do	Sashes, doors, and blinds	1	10½	12	5	
Do	...do	...do	...do	Saw	14	246	160	....	
Do	...do	...do	...do	Wheelwrighting	2	33	16	....	
Do	...do	...do	Litchfield	Agricultural implements	3	48	22	....	
Do	...do	...do	...do	Blacksmithing	1	8	10	....	
Do	...do	...do	...do	Chewing-tobacco	1	21	15	....	
Do	...do	...do	...do	Cutlery and edge-tools	2	39	37	40	
Do	...do	...do	...do	Flouring and grist	18	348	507	....	
Do	...do	...do	...do	Furniture	1	....	17	....	
Do	...do	...do	...do	Iron castings	2	29	35	....	
Do	...do	...do	...do	Iron and steel	5	92	383	60	
Do	...do	...do	...do	Machinery	2	70	31	....	
Do	...do	...do	...do	Marble and stone work	2	17	13	....	
Do	...do	...do	...do	Paper	2	38	97	....	
Do	...do	...do	...do	Sashes, doors, and blinds	4	68	74	....	
Do	...do	...do	...do	Saw	18	310+	331	....	
Do	...do	...do	...do	Silk	1	18	40	....	
Do	...do	...do	...do	Tannery	1	8	4	....	
Do	...do	...do	...do	Wheelwrighting	1	20	12	....	
Do	...do	...do	...do	Wooden handles	1	18	24	....	
Do	...do	New York	Dutchess	Carriages and wagons	1	3	10	....	
Do	...do	...do	...do	Flouring and grist	5	88	180	....	
Do	...do	...do	...do	Sashes, doors, and blinds	1	7	10	....	
Do	...do	...do	...do	Saw	5	85	72	....	
Do	...do	...do	Columbia	Flouring and grist	1	11	36	....	
Do	...do	...do	...do	Saw	3	32	55	....	
Do	...do	Massachusetts	Berkshire	Agricultural implements	4	73	56	....	
Do	...do	...do	...do	Cordage and twine	1	11	30	....	
Do	...do	...do	...do	Flouring and grist	17	283	538	....	
Do	...do	...do	...do	Furniture	1	17	15	....	
Do	...do	...do	...do	Iron and steel	1	17	40	120	
Do	...do	...do	...do	Kaolin and ground earths	1	4½	30	....	
Do	...do	...do	...do	Machinery	2	16	27	20	
Do	...do	...do	...do	Paper	8	335	713	597	
Do	...do	...do	...do	Plaster	1	13	50	....	
Do	...do	...do	...do	Saw	30	540+	700	32	
Do	...do	...do	...do	Shoddy	1	11	32	25	
Do	...do	...do	...do	Wood-pulp	2	33	70	30	
Do	...do	...do	...do	Woolen	6	158+	678	610	

V.—THE NORWALK RIVER.

This is a small stream lying in the southwestern part of Connecticut, and emptying into Long Island sound below South Norwalk. Its course is mainly through the towns of Ridgefield, Wilton, and Norwalk; the drainage basin is 15 miles long, 5 miles wide in the broadest part, and includes about 58 square miles. The Danbury and Norwalk railroad follows the stream closely through the greater part of its length.

The country embraced within the water-shed of the Norwalk river has a hilly surface. The stream itself has a large fall, amounting to 826 feet from the extreme source to the mouth, but being without storage reservoirs it runs very low in the dry season; for eight or nine months in an average year most of the mills have water enough, but for two or three months in the summer season there is a very scanty supply, hardly more than enough some of the time, as stated at one mill, for washing wool. Severe winter weather also brings down the stream, and it is at times low for a month from that cause.

In the town of Ridgefield there is a small reservoir of perhaps a dozen acres which, years ago, when the mills were much smaller, was a substantial help to the stream, but it is regarded as of little consequence now, and no attention has been paid to it for 15 years.

It is claimed that 15 or 20 miles from the mouth—that is, in the upper waters—a reservoir might be constructed at a cost of $20,000 which would be sufficient to carry the mills through dry weather, but they are generally provided with steam-engines and make no active movement toward reservoiring the stream, although it is evident that the power could be much improved thereby.

On the Union Manufacturing Company's dam, 140 or 150 feet long, the depth in freshets is frequently 3 or 4 feet, and in extreme cases 5 feet. Ice forms 10 or 12 inches thick in the mill-ponds, but usually rots before going out.

The lowest privilege on the river is that of the above-mentioned company, at Norwalk. There was formerly a dam 5 or 6 feet high below this, but on account of backwater it was purchased by the Union company and abolished. This company manufactures felt cloth and has also 6 sets of cards on fancy cassimeres. The dam is of rubble masonry and has a rock foundation. The fall is 21 feet 6 inches. Power is derived from a 120 horse-power overshot and a 75 horse-power turbine wheel. In low water the supply is insufficient for running even the turbine, and a 200 horse-power double engine is employed.

The stream is rather flat above until we reach Winnipauk. There the first power is occupied by the Lounsbury & Bissell Company, manufacturer of felt goods, its works being equivalent to a 13-set woolen-mill. The dam is an old structure of cement rubble-work. The head used is 12 feet, under which a turbine of 80 or 90 horse-power is run about one-half the year, while for two or three months it cannot be operated at all.

Next in order are the Norwalk Mills, using 18 feet fall and manufacturing fancy cassimeres; they run 12 sets of cards. The dam is of cement rubble, the head-race 600 to 700 feet long, and the tail-race say 250 feet. Power is taken from an undershot wheel 22 feet 9 inches in diameter and rated at 180 horse-power; it can be run about nine months in the year, but steam is relied upon the remainder of the time.

The stream was not examined above this point; there were reported to be occasional small saw- and grist-mills above Winnipauk, but no concerns of importance except at Georgetown, where the Gilbert & Bennett Manufacturing Company uses power in the manufacture of wire cloth.

Table showing the fall in the Norwalk river.

Locality.	Elevation of water-surface above tide.	Fall between points.	Distance between points.	Fall per mile between points.
	Feet.	*Feet.*	*Miles.*	*Feet.*
Source of stream	826			
		426		
Branchville	400		12	50.5
		25		
Georgetown	375			
		155		
Cannon's	220			
		39		
Wilton	181			
		57		
South Wilton	124			
		20		
Norwalk Mills	104		12	18.3
		24		
Winnipauk	80			
		58		
Norwalk bridge	22			
		22		
Mouth of stream	0			

Table of power utilized on the Norwalk river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Norwalk river	Long Island sound	Connecticut	Fairfield	Sashes, doors, and blinds	2	17	22	....
Do	do	do	do	Saw	2	23	60	....
Do	do	do	do	Toys and games	1	26	100	....
Do	do	do	do	Wire	1	9	10	....
Do	do	do	do	Wirework	1	16	50	80
Do	do	do	do	Woolen	8	56½	455	445
Tributaries	Norwalk river	do	do	Flouring and grist	1	16	12	....
Do	do	do	do	Saw	2	32	19	....
Do	do	do	do	Wood turning and carving	1	10	18	....

Table of power utilized on sundry small streams tributary to Long Island sound.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Mill river and tributaries	Long Island sound	Connecticut	New Haven	Cotton	1	8	40	80
Do	do	do	do	Fire-arms	1	34	150	....
Do	do	do	do	Flouring and grist	1	8	30	....
Do	do	do	do	Hardware	1	10	30	....
Do	do	do	do	Iron forgings	1	9½, 20	62	....
Do	do	do	do	Needles and pins	2	8+	18	....
Do	do	do	do	Saw	*a*4	87	86	....
Do	do	do	do	Silk	1	7	15	....
Tributaries	Westport river	do	Fairfield	Buttons	4	54+	45	14
Do	do	do	do	Cutlery and edge-tools	1	....	35	....
Do	do	do	do	Flouring and grist	3	28½	106	....
Do	do	do	do	Iron castings	1	....	10	....
Do	do	do	do	Mattresses and spring beds	1	4½	6	....
Do	do	do	do	Paper	1	14	30	....
Do	do	do	do	Trunks and valises	1	4½	12	....
Do	do	do	do	Wheelwrighting	1	....	3	....
Various other small streams	Long Island sound	do	New London	Cotton	2	24	38	....
Do	do	do	do	Flouring and grist	8	111	202	....
Do	do	do	do	Saw	7	95	117	....
Do	do	do	do	Wood turning and carving	1	10	6	....
Do	do	do	do	Woolen	1	18	60	120
Do	do	do	Middlesex	Flouring and grist	4	74	100	....
Do	do	do	do	Paper	2	42	100	70
Do	do	do	do	Saw	5	78½	69	....
Do	do	do	New Haven	Agricultural implements	1	15	10	....
Do	do	do	do	Boxes, cigar	1	20	5	....
Do	do	do	do	Boxes, wood packing	1	26	25	10
Do	do	do	do	Britannia and plated ware	1	20	20	25
Do	do	do	do	Carriages and wagons	1	10	10	....
Do	do	do	do	Flouring and grist	6	70½	70	....
Do	do	do	do	Iron bolts, etc	1	11	20	....
Do	do	do	do	Matches	3	31	61	110
Do	do	do	do	Paper	4	67	200	375
Do	do	do	do	Printing and publishing	3	34+	6	....
Do	do	do	do	Saw	6	88	127	....
Do	do	do	do	Sporting goods	1	10	16	....
Do	do	do	do	Tin-, copper-, and sheet-iron-ware.	1	10	10	....
Do	do	do	do	Wheelwrighting	1	12	65	....
Do	do	do	do	Window blinds and shades	1	18	6	8
Do	do	do	do	Wood turning and carving	1	10	18	....
Do	do	do	do	Woolen	2	35+	44	25
Do	do	do	Fairfield	Carriages and wagons	1	13	8	....

a On tributaries.

Table of power utilized on sundry small streams tributary to Long Island sound—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Various other small streams	Long Island sound	Connecticut	Fairfield	Children's carriages and sleds.	1	10	16	....
Do	do	do	do	Cigars	1	14	15	....
Do	do	do	do	Dye-woods, dye-stuffs, and extracts.	1	3	225	1, 500
Do	do	do	do	Flouring and grist	15	182	386	....
Do	do	do	do	Hats and caps	1	16	18	....
Do	do	do	do	Hat and cap materials	1	12	30	....
Do	do	do	do	Iron and steel	2	15	205	85
Do	do	do	do	Iron nuts, bolts, washers, and rivets.	1	40½	135	....
Do	do	do	do	Machinery	1	....	6	8
Do	do	do	do	Paper	3	56	130	....
Do	do	do	do	Pumps	1	15	85	....
Do	do	do	do	Saw	9	136	114	....
Do	do	do	do	Tools	1	28	35	....
Do	do	do	do	Wirework	2	21	26	....
Do	do	do	do	Woolen	4	80	216	200
Do	do	New York	Westchester	Buttons	1	4	13	25
Do	do	do	do	Flouring and grist	7	128	174	....
Do	do	do	do	Iron forgings	1	13	28	....
Do	do	do	do	Lithographing	1	7	10	....
Do	do	do	do	Saw	4	47+	73	....
Do	do	Connecticut	Fairfield	Flouring and grist (*a*)	2	13	68	....

a Tide-mills.

Summary of power utilized on streams

[From the Thames river on the east, to

	River.	COTTON-MILLS. Number of mills.	COTTON-MILLS. Water-power utilized.	COTTON-MILLS. Auxiliary steam-power.	SILK-MILLS. Number of mills.	SILK-MILLS. Water-power utilized.	SILK-MILLS. Auxiliary steam-power.	WOOLEN-MILLS. Number of mills.	WOOLEN-MILLS. Water-power utilized.	WOOLEN-MILLS. Auxiliary steam-power.	PAPER-MILLS. Number of mills.	PAPER-MILLS. Water-power utilized.	PAPER-MILLS. Auxiliary steam-power.
			H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
1	The Thames river tributaries	82	16,422	5,001	10	143	22	58	5,044	1,735	13	1,367	60
2	The Connecticut river and tributaries	88	16,434	4,370	13	517	851	107	8,378	2,753	104	23,538	2,034
3	The Quinnipiac river and tributaries												
4	The Housatonic river and tributaries	6	705	50	2	65	30	23	2,120	1,425	34	4,460	2,378
5	The Norwalk river and tributaries							3	455	445			
6	All other streams	3	78	80	1	15		7	320	345	10	460	445
	Total	179	33,639	9,501	26	740	903	198	16,317	6,703	161	29,825	4,917

With unimportant exceptions, the figures given in the table are based upon the census enumerators' returns,

NOTE.—The same remark may be made here that has already been made in connection with the table of utilized power on the of the mills running only at irregular intervals; and that, since paper-mills are usually operated night and day, the power credited to manufacturing industry should therefore really rank first, in the region we are considering, in respect to the extensive use of water-power.

It is also to be said that the item of "auxiliary steam-power" is introduced mainly to show the extent to which steam- and water-power for many of the mills enumerated, located on small streams, rely upon steam as an important, and even the major, portion of their regular

The division of *woolen-mills* includes also a few worsted-mills.

The division of *various metal-working establishments* comprises blacksmithing, lock- and gun-smithing shops, brass and iron founderies, britannia- and plated-ware, bronze statuary, clocks, coffin-trimmings, cutlery and edge-tools, dippers and hollow-ware, electrical apparatus nails, needles and pins, pumps, saws, screws, scales and balances, sewing-machines and sewing-machine materials, springs, steam fitting

The division of *various wood-working establishments* comprises carpentering, cooperage, wheelwrighting, and wood-turning and carving bobbins, canes, carriages and wagons, carriage and wagon materials, chairs, chair-stock, children's carriages and sleds, churns, coffins materials, rules, sashes, doors, and blinds, shoe-pegs, spools, washing-machines and clothes-wringers, wheelbarrows, wooden handles, and

The division of *sundry other establishments* comprises bleaching and calendering, dyeing and cleaning, electro-plating, lithographing, repairing shops, and establishments for the manufacture of baskets, rattan- and willow-ware, leather belting and hose, boots and shoes, chewing-tobacco, cigars, combs, cordage, corsets, drugs and chemicals, emery-wheels, explosives and fire-works, fancy and paper boxes whetstones, hosiery, horse-blankets, kaolin and ground earths, leather-board, linen, mattresses and spring beds, mosquito- and fly-nets, elastic goods, vulcanized rubber, rubber boots and shoes, rubber belting and hose, shoddy, soap and candles, spectacles, sporting goods,

tributary to Long Island sound.

the Bronx on the west, both inclusive.]

Flouring- and grist-mills.			Saw-mills.			Various metal-working establishments.			Various wood-working establishments.			Sundry other establishments.			Total.			
Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	
	H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*	
68	1, 887	70	99	2, 157	5	27	587	40	30	549	45	33	2, 367	885	420	30, 523	7, 363	1
303	11, 579	278	794	27, 194	1, 293	256	10, 547	2, 117	413	10, 842	1, 354	220	8, 997	997	2, 298	118, 026	16, 047	2
4	168	....	7	217	....	22	1, 812	903	5	67	15	2	14	....	40	2, 278	918	3
82	2, 614	20	110	2, 528	32	96	5, 747	5, 210	36	557	77	53	2, 363	1, 502	442	21, 159	10, 724	4
1	12	....	4	79	....	2	60	80	3	40	....	1	100	....	14	746	525	5
46	1, 136	....	35	586	....	20	885	118	13	223	128	16	396	1, 539	151	4, 099	2, 655	6
504	17, 396	368	1, 049	32, 761	1, 330	423	19, 638	8, 468	500	12, 278	1, 619	325	14, 237	4, 423	3, 365	176, 831	38, 232	

and represent the power in use in 1880.

Connecticut river and tributaries, namely, that the power credited to saw-mills, while large, is not all in continuous use, very many them should be largely increased in reckoning upon the same basis of daily working-hours common among other mills. The paper-

are combined in the same establishments, and is not to be taken as a proper measure of the deficiencies of the streams in the dry season; motive power, rather than merely as supplying the lack of power due to summer low water.

brass and copper rolling-mills, and establishments for the manufacture of agricultural implements, bells, bits and gimlets, brass-ware, and supplies, files, fire-arms, general hardware, hooks and eyes, horseshoes, iron forgings, iron bolts, nuts, washers, and rivets, machinery, and heating apparatus, stencils and brands, swords, tin-, copper-, and sheet-iron ware, watch and clock materials, wire and wirework.
shops, planing-mills, and establishments for the manufacture of billiard and bagatelle tables, cues and materials, cigar- and packing-boxes, and other undertakers' goods, excelsior, furniture, general house-furnishing goods, matches, models and patterns, picture molding, piano wooden ware.
marble and stone, calico printing, printing and publishing, soapstone, and wool-grading and scouring works; tanneries, watch- and clock-boot- and shoe-findings, bricks and tiles, brooms and brushes, butter and cheese, buttons, carpet yarns, crashes, twines, and bagging, and other fancy articles, fertilizers, food preparations, gloves and mittens, gunpowder, hats and caps and hat and cap materials, hones and mucilage and paste, musical instruments and materials, patent medicines and compounds, plaster, preserves and sauces, rubber and starch, stationery goods, tape, toys and games, trunks and valises, umbrellas, upholstering materials, vinegar, whips and lashes, whip

INDEX

TO

REPORT ON REGION TRIBUTARY TO LONG ISLAND SOUND.

REPORTS ON THE WATER-POWER

OF

THE HUDSON RIVER BASIN

AND THE

LAKE GEORGE OUTLET,

BY

DWIGHT PORTER, PH. B.,

INSTRUCTOR IN CIVIL ENGINEERING AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

SPECIAL AGENT.

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LAKE GEORGE OUTLET.

LIST OF ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

BOSTON, MASS., *July* 9, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York City.

SIR: I have the honor to submit a report upon the water-power of the Hudson River basin, based upon investigations carried on under your direction, mainly in the autumn of 1882. A short report upon the water-power at the outlet of lake George is also appended. It is desired to call attention to the principles observed in the estimates of flow and power, which are fully explained in connection with the report on the region tributary to Long Island sound.

Very respectfully,

DWIGHT PORTER,

Special Agent.

REPORT

ON THE

WATER-POWER OF THE HUDSON RIVER BASIN.

THE HUDSON RIVER BASIN.

GENERAL DESCRIPTION OF THE HUDSON RIVER AND OF THE REGION TRIBUTARY ABOVE TROY.

In the elevated mountain region of Essex county, in northeastern New York, are the principal sources of this important river. It takes a rather irregular southerly course till on the northern boundary of Saratoga county it turns abruptly to the eastward for a dozen miles or so by general course, and cuts its way through the mountains, forming, as it strikes across the rocky strata, several falls of great height and beauty. At Sandy Hill there is another quick turn, even more sudden than the previous one, and the direction of flow then continues southerly till the river empties into New York bay.

In its upper waters the Hudson is formed by a number of branches heading at points about equally remote from the mouth of the Sacondaga, and it is perhaps not easy to say that the main river has its origin with any one of these to the exclusion of the others; but if we assume the true head to be in the highest collected and permanent body of water, then the source of the Hudson river becomes lake Tear-of-the-Clouds, which lies at an elevation of 4,322 feet above tide, in the center of the triangle formed by mounts Marcy and Skylight and Gray peak, and the discovery of which source is claimed by Verplanck Colvin, superintendent of the Adirondack survey. From this lake to the mouth of the river the distance by water is probably not far from 300 miles.

Table showing the fall in the Hudson river.

Locality.	Distance from mouth. (Above Fort Edward distances are by map measurement.)	Height of water-surface above mean sea-level.	Distance between points.	Fall between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	
Lake Tear-of-the-Clouds	300	4,322				Colvin, *Survey of the Adirondack Region.*
			34½	2,868	83.1	
Mouth of Cedar river	265½	1,454				Profile of the Adirondack Company's railroad. (*a*)
			1	51	51.0	
Mouth of Indian river	264½	1,403				Do.
			7½	269	35.9	
Mouth of Boreas river	257	1,134				Do.
			4½	93	20.7	
North River village	252½	1,041				Do.
			4½	60	13.3	
Mouth of North creek	248	981				Do.
			8½	164	19.3	
Mouth of Mill creek	239½	817				Do.
			3½	97	27.7	
The Glen	236	720				Do.
			8	126	15.7	
Mouth of Schroon river	228	594				Do.
			5½	23	4.0	
Mouth of Stony creek	222½	571				Do.
			6½	35	5.4	
Mouth of Sacondaga river	216	536				Do.
			19½	251.7	12.9	
Crest of Glens Falls feeder-dam	196½	284.3				(282.25 feet + mean low-tide at Albany. *b*) New York canal profiles. Clark.
			6½	166.2	25.6	
Fort Edward railroad bridge	190	118.1				(116 feet + tide. *c*) Samuel McElroy, survey made in 1866.
			10	16	1.6	
Crest of Saratoga dam	180	102.1				(100 feet + mean low-tide at Albany.) New York canal profiles.
			30	100	3.3	
Troy (mean low-tide)	150	2.1				Estimated from mean low-tide at Albany. (*d*)
			150	2.1	0.014	
Mouth of Hudson river	0	0				

a The elevations along the Adirondack Company's line were furnished by C. E. Durkee, superintendent.

b At the United States Coast Survey office mean low-tide at Albany is given as 2.07 feet above mean sea-level in New York harbor.

c The elevations given by Mr. McElroy refer, as nearly as can be judged, to mean low-tide at Troy, which is probably 2.1 to 2.2 feet above mean sea-level in New York harbor.

d By Coast Survey measurements mean tide at Albany is 4.84 feet, and mean low-tide 2.07 feet (as previously stated) above mean sea-level in New York harbor.

No special information can be given here as to the manner in which the fall of the upper river is distributed, other than that afforded by the table above. The fall is certainly very rapid, amounting to about 64 feet per mile

on the average from lake Tear-of-the-Clouds to North creek, in which distance the stream loses nearly 80 per cent. of its altitude above tide, descending 3,341 feet in say 52 miles. From the mouth of North creek to the mouth of the Sacondaga the descent is 445 feet in 32 miles, or nearly 14 feet per mile; it is neither uniform nor made up of sudden pitches, but is distributed among rapids which diminish in frequency as the Sacondaga is approached. Thence, in the 26 miles to Fort Edward, the river loses 418 feet more of its elevation, or an average of something over 16 feet to the mile, but of this, 175 feet is comprised within the three abrupt pitches at Palmer, Glens, and Baker's falls, while most of the remainder occurs in the rapids between Jessup's Landing and the Ox-bow above Glens Falls. From Fort Edward to Troy the fall is comparatively small, being but 116 feet in 40 miles, or 2.9 feet per mile. Below Troy the Hudson is a tidal river, with an oscillation at that point, due to tides, of about 2 feet, and a fall from mean low water at Albany to mean low tide at Governor's island of only 4.2 feet.(*a*)

From the mouth to the city of Hudson the river is navigable for first-class ocean vessels, and to Troy for vessels of less draught. The only important obstructions to ordinary navigation lie between New Baltimore and Troy, and in 1880 consisted of 14 bars, 5 above and 9 below Albany, with water depths of from 8 to 11 feet. Much work has been performed, both by the national government and by the state of New York, for the improvement of the river, and from June, 1866, to June, 1881, the former expended $900,000 for that purpose. In the upper part of the city of Troy the state has a dam, the first encountered on the river, through the pool of which canal-boats bound north ascend to Waterford, where they enter the Champlain canal. This follows up the west bank of the river to a point about 2 miles above Schuylerville, where it crosses in the pool of the Saratoga dam to the east side, on which it continues to Fort Edward; it then leaves the river, and striking to the northeast passes on to Whitehall, at the head of lake Champlain. There is thus afforded a water-transportation route about 400 miles in length, from New York city to the Saint Lawrence, the business of which is large and is said to be increasing. Except in connection with the canal to the slight extent mentioned, the Hudson is not employed for navigation above Troy. A portion of its upper course is rendered accessible by the Adirondack Company's railroad, which runs northerly from Saratoga Springs and follows the west bank of the river at present as far as North Creek.

Drainage areas of the Hudson river.

Locality.	Sq. miles.
Below the mouth of North creek	753
Below the mouth of Schroon river	1,457
Below the mouth of Sacondaga river	2,626
Palmer falls	2,650
Glens Falls	2,716
Champlain Canal crossing	2,904
Schuylerville, above Fish creek	3,366
Mechanicsville	4,476
Troy	8,034
Albany	8,200
Above the mouth of Rondout creek	10,500
Mouth of Hudson river	13,366

NOTE.—Drainage areas in the Hudson River basin have been measured by planimeter on French's map of New York.

Excepting that of the Delaware, the basin of the Hudson contains a greater population in proportion to its size than any other important river basin in the United States. According to the statistics of Mr. Henry Gannett, the aggregate number of inhabitants increased from about 1,964,000 in 1870, to 2,280,000 in 1880, or from an average of 148 to 172 per square mile.(*b*) This population is largely concentrated along the great highway of traffic which follows the valley of the Mohawk from the west and then continues down the lower Hudson. In the vicinity of Troy there is a dense settlement, comprising within the limits of that city, Cohoes, and the villages of West Troy and Lansingburg, about 92,000 inhabitants. Albany has 90,000, Poughkeepsie 20,000, Newburg, 18,000, Hudson 8,700; and all along the river between Albany and the mouth are scattered villages ranging from four or five thousand inhabitants downward, while surrounding the mouth of the river there is one great hive of population, including about 1,900,000 souls within the three cities of New York, Brooklyn, and Jersey City. Ascending above the mouth of the Mohawk there are met in turn the following principal villages on the main river: Waterford, 1,800 inhabitants; Mechanicsville, 1,300; Stillwater, 900; Schuylerville and Victory Mills, 2,700; Fort Edward, 3,000; Sandy Hill, 2,500, and Glens Falls, 4,900. Above Glens Falls the course of the river lies through the mountains, in a contracted and often extremely rugged valley, showing occasional small villages, but ill-suited to extensive settlement.

After cutting its way through the rocky barriers which obstruct its passage, in the last important instance at Sandy Hill, the Hudson settles peaceably down into its final southerly course and follows along that great

a Report of the Chief of Engineers U. S. Army, 1873, page 154.
b The drainage area being assumed slightly less than as given above.

depression which extends almost due north and south between New York bay and the Saint Lawrence, and which offers such splendid facilities for commerce. It now runs with clear blue waters through an open and charming valley, bordered by cultivated farms and thriving villages, for the location of which the topography is finely adapted, the country rising with moderate slope from the river to the summits of high hills. Descending 20 or 30 miles below Albany, the Catskill mountains rise boldly into view on the right, and thence to the mouth the immediate valley is flanked by hills of considerable height, the Highlands of Orange county, and, still farther south, the precipitous faces of the Palisades, forming especially noticeable features of scenery on the west side.

Although the Hudson drains a total area of 13,366 square miles, yet, so far as regards water-power on the main river, excepting the single case of the state dam at Troy, which is below the mouth of the Mohawk, there is to be considered only a tributary region of about 4,500 square miles. The southern portion of this is hilly, moderately wooded, well-settled, and devoted in the open country to the raising of grain, peas, beans, flax, and potatoes, to stock-raising, dairying, and wool-growing. But probably three-quarters of the area drained above the Mohawk is mountainous in character, heavily wooded in general, and dotted with numerous lakes and ponds. The elevated region seems to reach its culmination in Essex county, at the head-waters of the Hudson and Au Sable rivers. Of the three peaks which stand like sentinels about lake Tear-of-the-Clouds, the most elevated lakelet source of the Hudson, mount Marcy towers to a height of 5,344 feet above tide; mount Skylight, 4,890; and Gray peak, 4,902. The whole surrounding district is broken up by rugged mountain masses, a large number of peaks attaining altitudes of 3,000, 4,000, and in several instances nearly 5,000 feet. The rocks belong to the oldest formation, and are mainly granite, gneiss, and mica-schist; they contain extensive deposits of the most valuable magnetic iron ore.

Save the rocky summits of the higher mountain peaks and their more precipitous slopes, the whole region known as the "Northern Wilderness" was originally covered with magnificent forests of pine, spruce, and hemlock. To a large extent these still remain unbroken, but it is only in the remoter districts that this holds true, and elsewhere the lumbermen have made sad inroads. Although the forests are, for the sake of the lumber they furnish alone, a grand resource and have proved a mine of wealth to the state, yet in so far as concerns the river the operations of cutting and preparing the timber are from beginning to end prejudicial. In a region such as that which the upper Hudson drains, with its steep, rocky, and impervious slopes, either immense artificial reservoirs, or the natural reservoir and regulator afforded by a general covering of vegetation, are absolutely necessary to insure the constancy of the streams. Little regard, however, seems to be paid to any such consideration by those engaged in the business of lumbering. The trees are cut apparently without discrimination and the branches are left to cumber the ground. Forest fires become started and spread with great rapidity through the tinder-like material. The very soil is thus so parched and burned that it cannot renew its covering of vegetation, and the surface presents a most desolate and forbidding appearance. Robbed of the protecting mantle of the forests, the winter snows are exposed to the direct rays of the sun, and, instead of acting as conserving reservoirs, are liable to precipitate sudden and disastrous freshets in the streams to which they drain. The rains of the warmer seasons drain more quickly than before into the water-courses, the ground then speedily dries and the streams sink away. Thus a liability on the one hand to heavier freshets, and on the other to lower water, tends to increase those fluctuations of volume which were troublesome enough under natural conditions. Mr. Colvin states that "the burnt region on the Boreas river and upper Hudson alone covers an area of from 40,000 to 60,000 acres of rolling semi-mountainous lands; desolate with burnt, blackened logs; ghastly, barkless, dead timber standing, and a partial undergrowth of worthless birch, aspen, and alder brush".

In order to float the logs down stream advantage is taken of high water, which is artificially augmented and prolonged by "tripping", or drawing upon, certain of the lakes that have been dammed for this purpose. Having been drawn down, no further attention is paid to them for the season. They gradually fill up again, tend to hold back the needed summer supplies from the streams, and as thus managed are evidently entirely valueless as reservoirs, increasing, rather than reducing as they should, the extremes of high and low water. Nor do the disadvantages to which the Hudson is subjected at the hands of the lumbermen come to an end till the manufacture of the lumber has been finally completed. At various points along its course from Glens Falls down to the Saratoga dam immense numbers of logs are annually sawed and great quantities of sawdust and slabs are thrown into the river, the channel of which becomes thereby seriously clogged. The sawing season on the Hudson includes within its limits about eight months of the year, the winter not being availed of for that purpose, as it often is on the Connecticut; but for from two and one-half to three months out of the eight many of the mills are stopped, either partially or entirely, by low water. Glens Falls is the most important point on the river for this industry, but there are also large mills at Sandy Hill, Fort Edward, and near Schuylerville. No accurate statistics regarding the amount of lumber annually sawed on the Hudson are at hand; it varies widely in different years, but, judging from such figures as were stated by the mill owners, it cannot fall far short, in an average year, of 90,000,000 of 100,000,000 feet at the nine or ten principal mills from the Glens Falls feeder-dam to the Saratoga dam.

Scarcely any recorded measurements exist of the discharge of the Hudson which have sufficient accuracy and definiteness regarding stage of water to be of great practical value in determining its water-power. The flow is artificially depleted at two points by withdrawals for feeding the Champlain canal. From above the village or Glens Falls a feeder opens from the river and follows down the left bank, striking the main canal to the southeast

of Sandy Hill. It is 7 miles long, and feeds both ways from the summit level of the canal—northward toward lake Champlain and southward down the Hudson valley—supplying water to about 23 miles of its length. October 1, 1878, a measurement was made to determine the amount withdrawn from the river by this feeder, which was found to be 234 cubic feet per second.(a) About 20 cubic feet per second of this is lost by leakage in the feeder, and is probably returned quite directly to the river. At Saratoga dam the river is again drawn upon to supply whatever water is necessary for the canal in the 24 miles thence to Waterford, where it opens out into the state pool in the Mohawk, opposite Cohoes. No statement as to the amount withdrawn at the Saratoga dam has been observed, but in his report upon the upper Hudson, Mr. Farrand N. Benedict estimates the total amount diverted for feeding-purposes above Waterford at about 330 cubic feet per second.(b)

At Palmer falls there is a favorable opportunity for determining the low-water discharge, and observations have been made at various times by Mr. Warren Curtis, superintendent of the Hudson River Pulp & Paper Company. Mr. Curtis states that the average low flow at that place, or for say the four months of least volume, is not far from 400 or 500 cubic feet per second, and that for one or two months it is not more than from 200 to 250 cubic feet per second. October 28, 1882, a measurement was made which indicated a discharge of about 390 cubic feet per second.

November 1, 1874, when the river was "almost at its minimum navigable stage", the volume was measured by Mr. Benedict at a point 1 mile above Waterford, and found to be 2,020 cubic feet per second. Estimating, as before said, 330 cubic feet to be diverted for feeding the Champlain canal, he considered the normal flow at the time to be 2,350 cubic feet per second.

In the report of the United States board of engineers concerning the improvement of the Hudson River navigation,(c) occurs the following remark:

It seems that the discharge of the Hudson River water between Troy and Albany, at its low stage, is only about 2,000 cubic feet per second, the mean being about 10,000 cubic feet, while during freshets the wharf streets of the capital are flooded.

These various data may be thus summarized:

Data concerning the flow of the Hudson river.

Locality.	Stage of river.	Drainage area.	Flow per second.	Flow per second per square mile.	Remarks.
		Square miles.	*Cubic feet.*	*Cubic feet.*	
Palmer falls	Average flow for say four lowest months	2,650	400–500	0.151–0.189	Flow as estimated by Mr. Warren Curtis.
Do	Average flow for one or two lowest months		200–250	0.075–0.094	Do.
Do	October 28, 1882		390	0.147	Measurement by Mr. Curtis.
One mile above Waterford	River almost at minimum navigable stage	4,517	2,020	0.447	Actual discharge, as measured by F. N. Benedict of the United States.
Do	do		2,350	0.520	Normal estimated discharge, including 330 cubic feet per second withdrawn by feeders above.
Between Troy and Albany	Low water	About 8,100	2,000	0.247	Discharge as given in report of the United States board of engineers.

Mr. Benedict was of opinion that the annual rainfall on the upper basin of the Hudson is as great as 64 inches, although he assumed only 58 inches in his calculations for a reservoir system. Mr. Colvin employs an assumed rainfall of 40 inches in his estimates as to the capacities of the streams in this region, and considers that figure to be under the truth. There are no published records of rainfall observations in the Adirondack region sufficient to determine with any accuracy the annual precipitation. The Smithsonian tables embrace valuable data for a large number of stations immediately surrounding this section, but none in the interior. The results of observations at a few of these points are as follows:

Rainfall on the outskirts of the Adirondack region.

[From Smithsonian records.]

Locality.	County.	Elevation above tide.	Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
		Feet.		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Plattsburg	Clinton	186	18	7.55	9.63	9.18	5.62	31.98
Potsdam	Saint Lawrence	394	20	6.20	10.15	8.38	3.90	28.63
Lowville	Lewis	846	23	6.96	10.04	9.09	7.46	33.55
South Trenton	Herkimer	835	10	12.82	14.78	13.25	13.05	53.90
Johnstown	Fulton	250	12	9.75	11.82	9.65	9.15	40.37
Granville	Washington	250	15	7.38	9.59	8.59	5.96	31.52

a *Report of the Superintendent of Public Works* for the year ending September 30, 1878, page 47. Of the 234 cubic feet per second, 126 was found to be wasting over weirs at various points along the canal, only 108 cubic feet being actually required for lockage, leakage, evaporation, etc.

b *Report on a Survey of the Waters of the Upper Hudson and Raquette Rivers*, 1874.

c *Report of the Chief of Engineers U. S. Army*, 1880.

If we take the average of observations for a dozen stations, forming a circuit about the district that is now under consideration, the rainfall is found to be about 8½ inches in spring, 11 in summer, 10 in autumn, 7½ in winter, and 37 for the year; but these amounts undoubtedly increase as the elevated country about the head-waters of the Hudson is approached.

Notwithstanding that the annual precipitation is of fair amount, and, as indicated above, is favorably distributed through the year, being greatest in the summer and autumn when the demands of evaporation are most heavy, still, if the data that have been given for flow are correct, it is evident that the low-water discharge of the river is quite small considering the nature and extent of country drained, apparently sinking to about 0.25 cubic foot per second per square mile of drainage area at and below the mouth of the Mohawk, and probably falling below 0.10 cubic foot at Palmer falls. The full explanation of this can only be surmised. It may be due in part to the steep and impervious character of the rocky drainage slopes in the mountains, in part, undoubtedly, to the clearing away of the timber, and in part to the slight extent to which the tributary lakes are availed of for keeping up the summer flow, their management for logging-purposes having, as has been seen, rather the reverse effect. It is not impossible, also, that there may be considerable loss of water at points through the rock substrata. The extensive leakage from the canal-feeder at Glens Falls illustrates how this might take place.

It is without question, however, that the low-water volume of the Hudson might be very greatly improved by the construction of reservoirs in its upper basin. The facilities for such works are unsurpassed. The entire region is dotted and interlaced by ponds and lakes, many of them of large size and fed from extensive drainage areas. It may be judged how numerous these are from the fact that although a great many are indicated on the state maps, yet in his report of 1874 the superintendent of the Adirondack survey announced the discovery of 200 ponds and lakes not before represented on maps. On the map of the upper waters of the Hudson and Raquette rivers, accompanying the report of Benedict's survey, not less than 175 ponds and lakes are shown tributary to the Hudson above Indian river, and the Raquette above and including Jordan river. All the principal affluents of the Hudson, at least above Troy, receive important accessions from lakes. In the absence of accurate and detailed maps it is not practicable to give special information here regarding most of these, but concerning the principal sheets of water available for reservoirs above Indian river reliable data have been afforded by the survey above referred to, and are briefly presented in the following table:

Principal reservoir sites at the head-waters of the Hudson river (above Indian river), as determined in a survey by Mr. Farrand N. Benedict in 1874.

Name of proposed reservoir.	Elevation above tide.	Drainage area.	Natural surface.	Flowage.	Total surface of reservoir.	Depth of reservoir.	Capacity.	Estimated supply per second for 100 days.	Estimated cost of dam.	Remarks.
	Feet.	*Sq. miles.*	*Acres.*	*Acres.*	*Acres.*	*Ft.*	*Cubic feet.*	*Cubic feet.*		
Blue Mountain lake	1,771	39.2	2,500	160	2,660	10	1,158,696,000	134	$7,300	Reservoir includes the three lakes, Utowana, Eagle, and Blue Mountain; lies naturally in Raquette basin, but via Long lake can be diverted to the upper Hudson. Estimated that winter and spring drainage would fill reservoir 1.87 time.
Raquette lake	1,745	94.1	5,300	1,500	6,800	10	2,779,128,000	321	6,600	Waters proposed to be diverted from Raquette river to Hudson. Estimated that winter and spring drainage will fill reservoir 1.87 time.
Forked lake	1,726	39.8	1,620	510	2,130	7	609,840,000	70	5,600	Waters to be diverted from Raquette to Hudson. Estimated that winter and spring drainage will fill reservoir 3.6 times.
Beach's lake	....	8.6	640	160	800	8	250,905,600	29	2,100	Tributary to Forked lake. Estimated that winter and spring drainage will fill reservoir 1.88 time.
Long lake	1,614	155.4	3,000	4,575	7,575	20	5,912,834,400	684	*a* 14,000	This lake naturally drains through the Raquette river, but, by cutting a canal across a low divide, can be connected with Round pond, and thus be made tributary to the Hudson. Estimated cost of bulkhead, canal, and outlet through slough at foot of lake, $154,600. Estimated that winter and spring drainage will fill reservoir 1.056 time.
Round pond	1,618	....	....	....	640	10	278,784,000	32	....	From Round pond to Catlin lake there is a fall of 35 feet in about 4,000 feet.
Catlin lake	1,583	31.1	1,040	500	1,540	18	815,443,200	94	22,000	Estimated that winter and spring drainage will fill reservoir 2.1 times.
Rich lake	1,549	67.1	600	400	1,000	20	609,840,000	70	28,600	Northern shore heavily wooded; southern cleared. Outlet narrow and rocky, with bold shores. Proposed dam would flow about 200 acres of improved land.
Harris lake	1,540		720	600	1,320	15	627,264,000	73	16,700	Estimated that winter and spring drainage will fill Rich and Harris Lake reservoirs about 3 times. Harris lake is the lowest member of a chain composed of those lakes mentioned above.
Lake Henderson	....	....	....	....	....	12	209,088,000	24	5,800	
Newcomb lake	1,699	30.6	640	200	840	15	483,516,000	56	13,800	Estimated that winter and spring drainage will fill reservoir 3.5 times. This lake is surrounded by high mountains on every side except the east.

a Total cost of Long Lake improvement estimated by Mr. Benedict at $196,600.

Principal reservoir sites at the head-waters of the Hudson river (above Indian river), etc.—Continued.

Name of proposed reservoir.	Elevation above tide.	Drainage area.	Natural surface.	Flowage.	Total surface of reservoir.	Depth of reservoir.	Capacity.	Estimated supply per second for 100 days.	Estimated cost of dam.	Remarks.
	Feet.	*Sq. miles.*	*Acres.*	*Acres.*	*Acres.*	*Ft.*	*Cubic feet.*	*Cubic feet.*		
Lower Works reservoir	....	57.2	....	....	2,000	15	1,306,800,000	151	$24,700	Estimated that winter and spring drainage will fill reservoir 2.4 times. Advantages for dam not so good as at some of the other sites. Includes lake Sandford.
Chain lakes	....	14.9	1,680	300	1,980	10	862,488,000	100	6,000	Estimated that winter and spring drainage will lack 5 per cent. of filling the reservoir.
Goodenow pond	....	0.25	320	....	....	6	83,635,200	10	7,900	Reservoir to be formed by dam on Goodenow river. Estimated that winter and spring drainage will fill reservoir 4.13 times.
Goodenow River reservoir.	....	7.8	....	480	....	12	250,905,600	29	8,800	Reservoir to be formed by dam on Goodenow river. Estimated that winter and spring drainage will fill reservoir 1.72 time.
South pond	1,769	....	....	....	....	12	188,179,200	22	5,000	Drain to Long lake.
Clear pond	1,691	....	....	....	....	10	217,800,000	25	7,000	
Slim pond	....	....	....	....	....	10	196,020,000	23	5,000	
Ackerman pond	....	....	....	....	....	10	87,120,000	10	5,900	Tributary to Catlin chain of lakes.
Perch pond	....	....	....	....	....	12	167,270,400	19	3,300	Drain through central or mountain branch of Hudson.
Trout pond	....	....	....	....	....	12	125,452,800	14	4,400	
Lake Harkness	....	....	....	....	....	12	104,544,000	12	3,100	
Shedd lake	....	....	....	....	....	10	209,088,000	24	4,100	Drain to Raquette lake.
First Sergeant pond	....	....	....	....	....	10	87,120,000	10	3,900	
Third Sergeant pond	....	....	....	....	....	10	217,800,000	25	3,200	
Plumley pond	....	....	....	....	....	11	258,746,400	30	4,100	Drain to Forked lake.
Moose pond	....	....	....	....	....	11	182,080,800	21	5,500	
Cary pond	....	....	....	....	....	10	139,392,000	16	4,772	
							18,419,781,600	2,128	*a* 229,172	

a Aggregate cost of improvements, including $14,800 for dam to control Little Tupper lake (designed in Mr. Benedict's plan to be used as a reserve for both the Hudson and Raquette rivers), and a total of $196,600 for Long lake, placed at $426,572.

It is thus seen that at an estimated expense of between $400,000 and $500,000 a probable supply of about 2,000 cubic feet per second from storage alone may be assured to the Hudson above the mouth of Indian river during three months or more of the dry season. It is a remarkable fact that, owing to the peculiar topography of the summit region about the adjacent sources of the Hudson and Raquette rivers, a reservoir capacity of over 10,000,000,000 cubic feet, properly belonging to the latter stream, may easily be diverted to the former. The particular reservoir sites that have been mentioned pertain to the extreme upper waters of the main Hudson, but upon all its principal tributaries below—the Cedar, Indian, Boreas, Schroon, and Sacondaga—there are abundant opportunities for extensive storage. In Mr. Benedict's report a list is given of 12 lakes and ponds in the Schroon River basin suitable for reservoirs, with an aggregate area of over 12,000 acres, a capacity of 5,900,000,000 cubic feet, and which are estimated capable of furnishing together a supply of at least 600 or 700 cubic feet per second during 100 days. Piseco lake, in the upper waters of the Sacondaga river, covering about 4 square miles, as represented on French's map, is controlled for log-driving purposes. Indian lake, tributary to Indian river, also having an area of 4 square miles,(*a*) is provided with a dam at the outlet, but the structure is poor and leaky, and the lake does not usually fill. Still, as it is, the water being held back longer than in most of the lakes, Indian lake affords, when "tripped" during the summer, about ten days of good sawing at Glens Falls. Although the building of reservoirs in the upper waters would benefit all the hydraulic powers on the course of the river below, it does not seem probable that their construction will be attempted by private capital. The mill-owners consider that the state would receive as much advantage from reservoirs, by reason of the improvement of low-water navigation below Troy, as any private interest would receive, and are not disposed to invest their own capital in such enterprises so long as there is a possibility that they may be undertaken as public works.

Above Glens Falls the largest tributaries of the Hudson are the Schroon and Sacondaga, the former entering from the east and the latter from the west. Between Glens Falls and Troy the Batten Kil and Hoosac river are received from the east and the Mohawk from the west. Below Albany the main river is joined from either side by numerous tributary creeks, of which the most important in point of drainage area is the Rondout.

The bed of the river above Troy is almost everywhere firm, and is generally composed either of solid rock at the surface, or of rock overlaid to a moderate depth by gravel. The banks are firm and of good height. The stream usually sinks lowest in August and September, and is regularly visited by freshets in the spring, with an occasional considerable rise in the fall. The flood heights above low water, as given in a report by Mr. Samuel McElroy,(*b*) range from 13 to 18 feet between Troy and Fort Edward, but it is reported on good authority that within

a By map accompanying Benedict's report.
b See *Annual Report of the State Engineer and Surveyor* for 1867.

the past 25 years there has been a rise of 22 feet below the Troy dam. Severe winter weather lowers the volume, but never to such a point as is reached in summer and fall. Anchor-ice runs heavily at times, and is especially complained of at Fort Miller. Gorges of cake-ice form at certain favorable points, as at Troy and Fort Miller, and cause considerable trouble by backwater.

The present use of water-power on the Hudson is confined to the localities of Troy, Stillwater, the Saratoga dam, Fort Miller, Fort Edward, Sandy Hill, Glens Falls, Palmer falls, and Hadley. Between Mechanicsville and Stillwater there is an old dam, but there was no power in use at the time it was visited. Opposite the upper part of the former village a fine privilege, commanding the flow from nearly 4,500 square miles of drainage area, has been developed, and a splendid dam of stone has been nearly completed. The manufacturing on the river by water-power is mainly limited to lumber, paper, and wood-pulp, to which the connection with the extensive forests in the north especially adapts it. Although below Glens Falls the available sites on the river are generally occupied, there is yet opportunity to establish an important power between Waterford and Mechanicsville, with probably 18 feet fall; immediately below the Saratoga dam there is an unimproved fall of perhaps 8 feet, and at Glens Falls one of 15 feet. Above Glens Falls, in its course through the mountains, the river is but slightly developed, and presents numerous sites that might be improved for power.

WATER-POWERS ON THE MAIN RIVER.

Power at Troy.—This privilege is located at the head of tide-water, the tide rising and falling 1 or 2 feet at the dam. There is navigation for steamers south 150 miles to New York, and a lock at the east end of the dam permits the passage of canal-boats to and from Waterford, at the entrance to the Champlain canal.

The dam runs across between the upper part of Troy, which is on the east bank, and Green Island, as it is called, on the west bank of the Hudson. It curves up stream slightly, and is 1,100 feet long, with a lift of 10 feet at low water. It is a log crib-work filled in with stone, and on top has a long slope of 30 or 35 feet down stream, ending in a vertical face a few feet in height; the sloping top, which serves also in part the purpose of an apron, is covered with round logs laid in the direction of flow. This dam was built by the state in 1826, and though frequently repaired since, the original structure still stands, but evidently permits a considerable leakage of water. It abuts against timber facing which on the east side is continued down past the mills. The nature of the filling opposite the dam, between it and the lock, is not apparent.

The principal use of power is on the Troy side. The hydraulic canal there opens from the pool a short distance above the lock and runs about 1,200 feet, approximately parallel to the river. In the upper portion this race is 60 feet wide, with a water-depth of 7 feet. For 700 feet from the head it is open; it then contracts, and the water passes through a 20-foot arched opening, in which it continues the rest of the way, the diameter of the opening growing less, however, toward the end. Near the head of the race there was once a wooden bulkhead, but it is now entirely in ruins and can not control the flow in the least. There is a waste-weir or some sort of escape in the lower part of the canal, but there being no head-gates it would of course be impossible to draw down the canal without building a coffer-dam.

When the state built the dam it reserved the right to all water necessary for lockage and slack-water navigation to Waterford, and leased the surplus. Previous to 1853 there were a cotton factory and a number of flouring-mills here, but they were destroyed by fire, and a decline in the flouring interest in this section prevented a continuance of that business. Power is now used on the east bank by five concerns. These are associated as the Troy Hydraulic Company, which has a lease directly from the state, for 999 years, of one-half the surplus water at this dam. Each mill-owner is a stockholder in the company, pays his water rental directly to it, and the company in turn pays to the state according to the terms of its lease. As the privilege was originally laid out, the hydraulic company owned 10½ lots lying between the canal and the river, each full lot having 60 feet frontage and an equal share to the water with every other lot. Every lessee therefore controls a proportion of water according to the number of lots which he owns, and the privilege comes to be divided as follows on the Troy side:

Orrs & Co., manufacturers of printing, book, and hanging papers, own five-elevenths.

Warren Brothers own two-elevenths, and sublet to Manning & Paine, manufacturers of manila paper.

George M. Tibbits' estate includes one-eleventh, the property being sublet to William Collins for a sash and blind factory.

John A. Manning owns two-elevenths, and uses the power in a manila paper-mill.

O. Boutwell & Son own one eleventh, and run a grist-mill.

Although the power is thus nominally divided, no measurement is ever made of the water actually used. The combined volume of the upper Hudson and the Mohawk flows past this point, but the use of water-power is nevertheless subjected to several disadvantages. The state will not allow the pool above the dam to be drawn down at all, as it is necessary to preserve sufficient depth for slack-water navigation to Waterford, and it thus happens that the mills on the Troy side are frequently called upon to shut down during low water. Taking the average for the year, it is claimed that a fall of about 7 feet is realized here. The extreme head available in low water is perhaps 3 or 4 inches over 10 feet, but on the whole the fall is very variable, being affected by three

causes: First, the tide produces a daily oscillation of 1 or 2 feet. Second, the fall is lessened, and sometimes entirely destroyed, by freshet backwater. In the past 25 years the extreme rise in the river below the dam, as stated by Mr. William Orr, has been 22 feet above low-water mark. The ordinary rise ranges from 12 to 20 feet and obliterates nearly all fall at the dam. Observation has shown that for every foot of rise above the dam there is about 2 feet of rise in the river below, so that when the water-surface reached a height of about 10 feet above the dam the river would be flowing smoothly over the structure. Very high water does not last more than a few days, but for a month the backwater is sufficient to cause more or less trouble. Third, the fall is similarly lessened by backwater due to ice-gorges. Below the dam the river is wide and contains extensive gravel flats. At various points on these flats, and sometimes against the bridge-piers between there and Albany, the ice collects and occasions serious trouble to the mills. The gorges do not seem to break up readily, as on most rivers, but at times cause a set-back in the river below the dam lasting for several weeks.

On the whole, it is estimated that in an average year the mills are forced to shut down for from four to six weeks from the various causes mentioned, and for a still longer period their power is somewhat curtailed. In 1873 the ice started down the river January 17, and from that time till February 5 no power was available at this privilege on account of a gorge below.

On the west side of the river the power is held under a perpetual lease from the state by the heirs of George M. Tibbits, deceased, who also own a valuable river frontage extending some distance down stream from the dam. A small amount of power is sublet to Crampton & Belden and M. L. Filley, manufacturers, respectively, of blinds and stoves, and the balance remains available for further lease. The race at this end of the dam is short, as the concerns noted above are close at hand. It is without any bulkhead, and in winter becomes choked with ice so as to give a great deal of trouble. As the power used is much less than on the Troy side, the mills are seldom shut down from low water, and there have been but one or two such occurrences in ten years. In 1880 a total of about 1,300 horse-power was in use at the state dam, including the privileges on both sides of the river.

From Troy to Mechanicsville.—Ascending from Troy, the river is found to be between 700 and 800 feet wide at Waterford bridge, and is there subject to an ordinary spring-freshet rise of 6 or 8 feet, while in the fall of 1868 or 1869 it rose 15 feet. About a mile above Waterford there is a long rocky shoal, and another from 2 to 2½ miles below Mechanicsville. Opposite this latter shoal the west bank is 15 or 20 feet high and succeeded by level land; the east bank is lower, and beyond it is a meadow perhaps a quarter of a mile in width. Generally speaking, the river between Waterford and Mechanicsville is wide and much of the way shallow, and contains a number of islands rocky and timbered. This portion of the river is of importance, as it is considered that still another power, at least equal in capacity to the fine one just improved at Mechanicsville, can be established. The results of McElroy's survey indicate a fall from the foot of Howland's dam above Mechanicsville to mean low-tide below the state dam at Troy of 61.75 feet in a distance of 13½ miles. If we allow 4 feet of unimproved fall between Howland's dam and slack-water from the new dam below, 16 feet fall to the Mechanicsville power, and 10 feet to that at Troy, there remains 31.75 feet undeveloped in the section below Mechanicsville. A certain part of this is necessary for the flow of the river; but it seems probable that if the banks prove of sufficient height a fall of 18 feet, which is the amount said to be claimed for the proposed privilege, could be obtained without difficulty.

Estimate of power available between Troy and Mechanicsville.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*18 feet fall.*	*30 feet fall.*
Low water, dry year							900	102.24	1,840	3,070
Low water, average year	9	12	10½	8	39½	4,500±	1,000	113.60	2,040	3,410
Available 10 months, average year							1,600	181.76	3,270	5,450

Power at Mechanicsville.—The development of the privilege now to be described, by the Hudson River Water Power & Paper Company, was carried on during the year 1882, and by the latter part of October of that year had been far advanced. The prime movers in the enterprise were Messrs. Wilkinson Brothers & Co., of New York city, who are also the principal shareholders.

The location chosen is immediately above the village of Mechanicsville, where the river is crossed by rock ledges and has banks firm and of good height on each side. On the west the land has a gentle slope beyond the immediate bank, while on the east the rise from the river is succeeded by a level meadow. Rocky shoals extend some distance up stream, and also run somewhat below the dam, but the latter is near their foot, and no material fall is gained beyond its height. An excavation for the east end of the dam showed the bank there to be composed of shale to within a few feet of the surface, and then of a light sandy soil. The structure rests throughout upon slate rock which is full of seams. The seams are not open, however, so as to permit leakage under the dam; at least

FIG. 1.—New dam at Mechanicsville during construction.

no leakage had been perceptible under a head of 6 or 8 feet, and it was not anticipated that there would be any. The slate remains compact and firm so long as under water, but upon exposure to the air crumbles into fine flakes and splinters, and finally forms a clayey soil.

The facilities for constructing a dam at this locality were excellent. The Champlain canal runs along the west bank but a few hundred feet from the river, and a temporary tramway was extended directly to the dam. So convenient were the arrangements, that it was possible to remove a stone from a canal-boat and lay it in position, 1,500 feet distant, at the farther end of the dam, in five minutes. A short distance beyond the Champlain canal is the line of the Boston, Hoosac Tunnel, and Western railroad. Close at hand is the village, well built up, with stores and churches, and having railway communication by two lines—the one just mentioned and that of the Delaware and Hudson Canal Company.

At the site of the dam the river was naturally of pretty uniform depth all the way across, ranging from 1 to 2 feet in low water; but there were two channels, one 6 feet deep and the other 9 or 10 feet deep and 40 or 50 feet in width. Across the latter channel the masonry has a total height of 25 feet and an equal width at base. For 7 or 8 feet down stream from the foot of the dam the river-bed has been blasted out to an average depth of 2 feet to receive an apron which will undoubtedly be added. The masonry work is all composed of a blue siliceous limestone obtained at Sandy Hill and brought by canal. The stone is said to answer well for rough work, but it is difficult to give it a fine finish. Sand was procured at Sandy Hill and at other points less remote, but little or none from the spot. For the lighter and more exposed work, such as the bulkhead piers, Portland cement was used, but for the main portion of the dam Rosendale cement was employed.

Construction work was begun at the west end; first the canal walls at that point were built, then the bulkhead was carried up till the capstones had been laid across the gate-openings, and afterward the dam was steadily extended toward the east shore. It was originally designed to complete it in 100-foot sections, but this plan was not followed; in fact, there was no especial system in this respect.

An important feature of the work was a railroad or tramway extending the whole length of the dam and used in transporting material. It was supported on bents placed about 12 feet apart. Each bent consisted of two upright posts, sloping inward slightly toward the top, with a capping piece and braces. The posts were 10 inches square, of spruce and pine, and the capping-pieces were 10 inches square or 10 by 12. The dam being 18 feet wide at the base, a clear space of 2 feet was left on either side to the bottoms of the posts; in other words, the latter were 22 feet apart. This system of trestle-work supported 6 iron rails; the 2 outer rails came about over the tops of the posts and served as a track for the "travelers", which will be described later, to move upon; between these was a double line of tracks for the gravity cars. From the Champlain canal to the river-bank, say 500 feet, there is a moderate descent, and still more down to the dam. The stone was unloaded from the canal-boats at a point opposite the end of the dam, a single line of track running down toward the latter and branching by a switch into a double track before reaching the edge of the bank. These tracks had a grade of about 10 feet in 300, but when fairly out upon the dam became level, and so continued the rest of the way across. The cars employed appeared to be common hand-cars fitted with a brake at one end. When loaded with stone or other material, one man operated the brake, and the grade of the inclined portion of the railway was sufficient to carry the car by its momentum to any portion of the work, even to the farther end of the dam. After being unloaded, the car was pushed back by hand to the foot of the incline and then hauled up by a rope.

The "travelers" were simply upright frame-works, consisting of a bent over each of the two rails on which they moved, with a platform at the top, and the whole suitably braced. The machine was given a motion along the track by a man standing on either side and working a cogged-wheel arrangement. From the platform overhead a stone was supported by chains and a transverse motion was obtained by men working on the platform. Two motions at right angles to each other were thus given, and a stone could be deposited at any desired point.

The coffer-work was not so expensive a feature in this dam as is often the case. For a portion of the distance a simple breastwork of chipped stone, blasted from the river-bed in the process of work, was made and puddled with clay on the up-stream surface. About 100 feet, mainly in the deep channels, consisted of timber crib-work filled in with loose stone and faced with sheet-piling, its upper surface puddled with clay. To a considerable extent the trestle-posts were also made use of in constructing coffer-work. Longitudinal pieces were fastened on their outer faces, and against these sheet-piling was driven; horizontal planking was secured to the inner faces of the posts, and the space between this planking and the sheet-piling filled in with clay. The trestle-posts were also used in the channel-ways, where, as has been said, crib-work was built, for supporting the cribs.

The front of the dam is rock-faced ashlar-work, and the coping is of cut stones 8 feet 10 inches long, sloping somewhat up stream. The ashlar courses range from 1 foot to 2½ feet in thickness, and are well bonded into the backing, which is rubble-work. From the crest to low-water surface at the foot of the dam the fall is 16 feet. The length of coping between abutments, that is, the length of roll-way, is 795½ feet. The total distance between abutments, including the bulkhead, is 928 feet. At the east end of the dam there was to be a supplementary embankment 500 feet long and 6 feet high next the river. The Mechanicsville dam has a base, in general, of about 18 feet, and has been so designed and constructed that if found desirable its height can be raised from 16, the

present figure, to 20 feet. The abutments rise 10 feet above the crest. That on the east side of the river extends from the upper base-line of the dam down stream to a point 20 feet below its face, and has two wings, each projecting 6 feet into the bank.

The bulkhead, which, as we have seen, is adjoining the west shore, is entirely of cut-stone masonry. It measures 20 feet in the direction of flow, and contains 12 gate-openings, each 10 feet high in the clear. Eleven of these have each a clear width of 7 feet 4 inches, and the remaining one is of half that width. The piers which separate them have each a minimum thickness of 2 feet, and a maximum, adjoining the gate recesses, of 32 inches. The gate-openings are rectangular in shape, and are controlled by wooden gates operated by a turbine, for which there is a wheel-pit in the abutment.

The canal running from the bulkhead is 115 feet wide in the clear, with a water-depth of 16 feet. It is formed by inclosing the part of the river next the west bank by masonry walls, and thus has for its bottom the natural bed of the river. The wall on the outer or river side is, for the first 150 feet below the dam, a waste-weir of the same height and construction as the dam, but with a base of 14 feet and with coping-stones 8 feet long. It contains two gates adjoining the dam, for drawing down the canal. From the end of this weir the river-wall was designed to be continued of the same dimensions as the former, but built entirely of rubble. The canal on this side was to be extended for the present 400 feet below the bulkhead. The water-power company owns land which will admit of giving it a total length of 1,000 feet, and it was stated as probable that an extension to nearly or quite that length would be made another season. This canal will closely follow the river-bank, the mills to be located on the inshore side discharging their tail-water in tunnels beneath the canal. The available fall is 16 feet.

The property of the company on this side of the river embraces 40 acres of land, and at the time it was visited extensive buildings were being erected for the manufacture of wood-pulp, with a productive capacity of 15 tons per day. The pulp-works were to have a river frontage of about 420 feet, and comprised buildings of the following dimensions: mills 60 by 170 feet, 50 by 136, 36 by 100, 25 by 48, 50 by 172, and 36 by 100; a boiler-house 42 by 50 feet, and a storehouse 40 by 160 feet. All of these buildings were to be two stories high on the river side, and some one story, some two stories on the shore front; they were being constructed of bricks made at the company's own kilns about a mile away.

It is planned ultimately to run a canal down the east bank also, in which case water would be taken out some little distance above the dam, the mills to be placed between the canal and the river. The company owns 110 acres of land on that side of the river, sufficient for extending the canal a quarter of a mile, and the topography is suitable for continuing it a much greater distance if desired.

The estimated cost of the dam, abutments, bulkhead, and canal-walls (including waste weir) for 400 feet in length had been $168,000, but it was stated by the treasurer of the company as probable that the actual expense would be slightly less than that amount. Some preliminary work was done in the latter part of May, 1882; the first stone was laid June 30, and by the latter part of October the dam had been completed except a short section adjoining the east shore, and the east abutment. The bulkhead on the west side had been carried up to include a single layer of stone covering the gate-openings, and the waste-weir with connecting river-wall was partially finished. It was expected that the whole of this work would be brought to a close by the middle of November. The construction had been prosecuted with a singular freedom from hinderances such as often embarrass similar undertakings. The only mishap encountered was the loss, during a September freshet, of a short section of trestle-work worth perhaps $1,500. The contractors for the work were Messrs. Smith & McGaw, of Philadelphia. About 75 men were usually employed on the dam. The working plant included 4 "travelers", 10 or 12 boom-derricks, and as many portable engines. For pumping, a No. 6 Andrews pump was employed, and also a cataract-pump.

The policy of the company regarding the use of this finely-developed power was stated not to have been fully determined upon, and it was undecided whether or not power should be rented to outside parties.

It is a difficult matter to make a reliable estimate of the power available at Mechanicsville. As has been elsewhere stated, no prolonged system of direct measurements of the flow of the river has been made at any point; the rainfall on the drainage basin is not known with much exactness, and but little is known, except by comparison with other streams, as to the ratio which drainage bears to rainfall in this basin, or its distribution through the year. In the prospectus of the water-power company, Mr. Peter Hogan, consulting engineer, certifies that the minimum discharge of the Hudson at the lowest stage of water of which there is any record amounts to 2,500 cubic feet per second for this locality. This certainly appears to be too high an estimate of the discharge. It is about 500 cubic feet more than was found by actual measurement 1 mile above Waterford by Mr. F. N. Benedict, November 1, 1874, and is an equal amount in excess of what has been assumed by the United States board of engineers as the combined low-water discharge of the upper Hudson and the Mohawk between Troy and Albany. If this privilege is to be utilized wholly for paper and pulp manufacture, in the processes of which mills run continuously throughout the 24 hours, then the storage above the dam, although useful in compensating for daily irregularities of flow, is not of special importance as otherwise increasing the available power. At all events, on account of the shoals extending steadily up stream from the dam, with rapid slope, the pondage is not large in comparison with

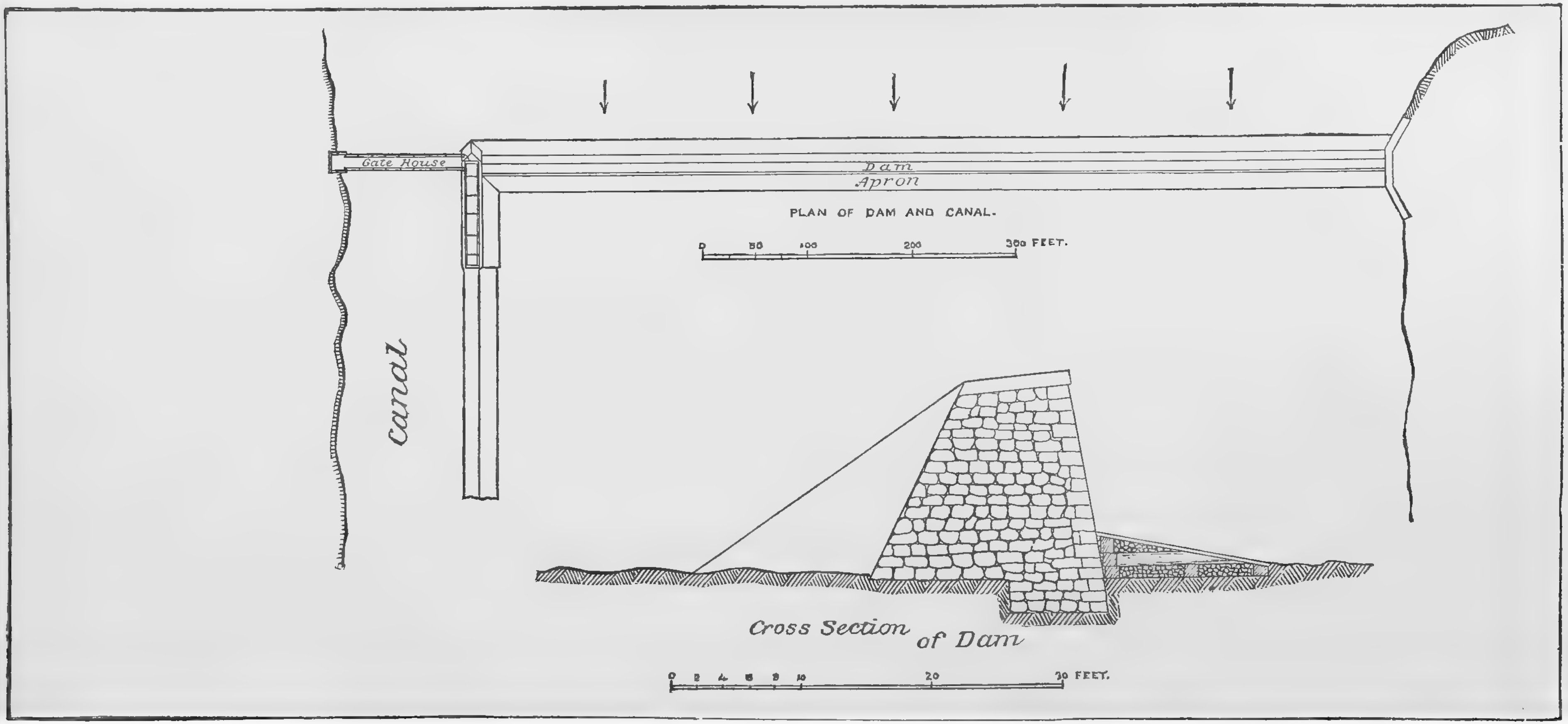

FIG. 2a.—Hudson River Water-Power and Paper Company's privilege.

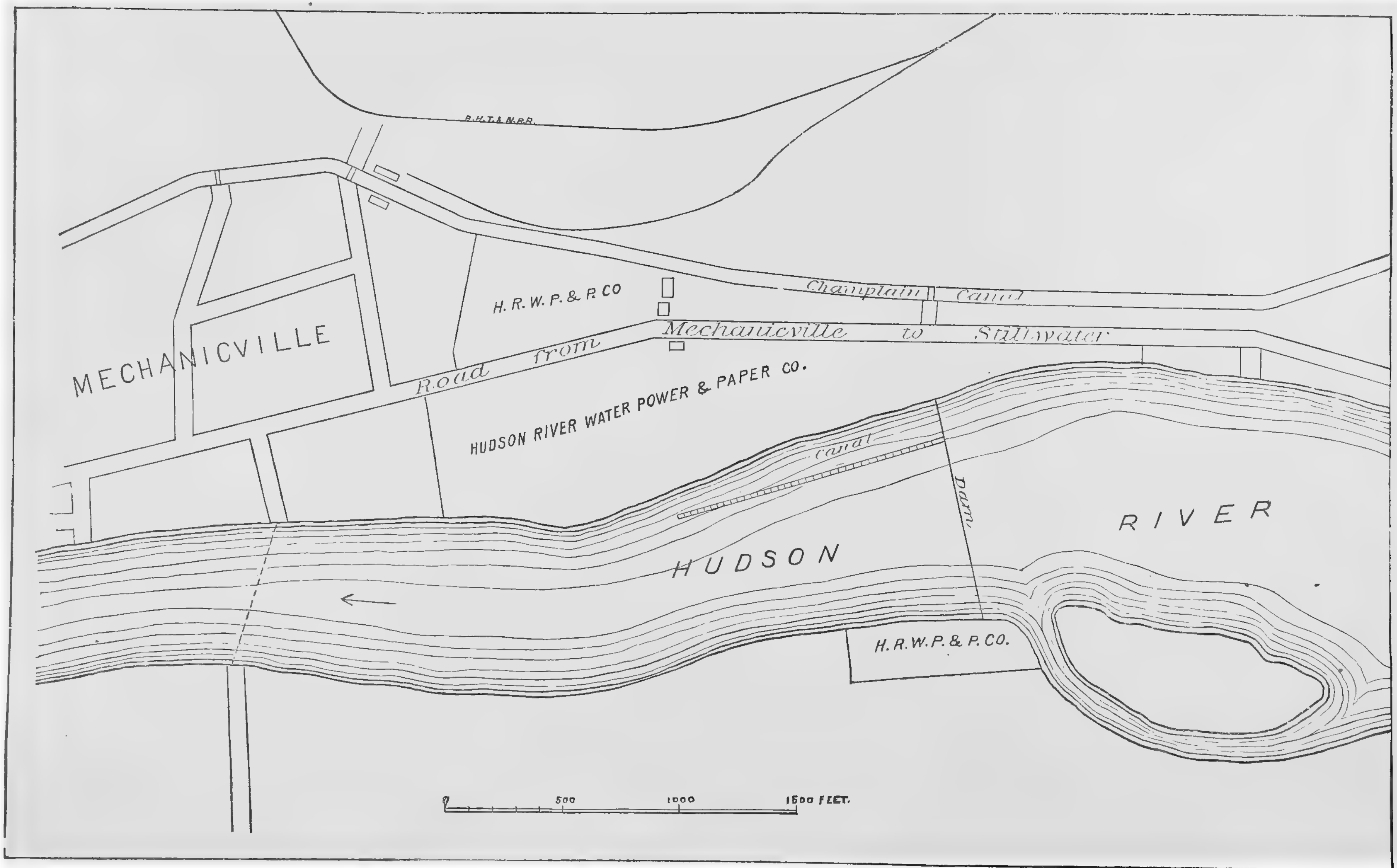

FIG. 2b.—Hudson River Water-Power and Paper Company's privilege.

the average flow for the 24 hours. Without reference to storage, the theoretical power of this privilege may be placed at the figures given in the accompanying table:

Estimate of power at Mechanicsville.

Stage of river.	Approximate rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	16 feet (present) fall.	20 feet fall (available by raising dam 4 feet).
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	9	12	$10\frac{1}{2}$	8	$39\frac{1}{2}$	4,476	900	102.24	1,640	2,040
Low water, average year							1,000	113.60	1,820	2,270
Available 10 months, average year							1,600	181.76	2,910	3,640

Perhaps three-quarters of a mile above the privilege just described is what was formerly known as Howland's dam, the power at which was until recently occupied by the Saratoga Paper Company for the manufacture of straw paper. The dam is a log structure with 8 feet fall, and has a very dilapidated appearance, it having sunk in places so as to give the crest an irregular height. It runs out from the west bank to an island in mid-stream, where it abuts against a vertical rock bank. Its foundation is also rock throughout its length, but the west abutment seems to be a kind of crib-work filled in with stone and other material. Water enters to the mill by first passing through an inclosure formed by extending the abutment of the dam up stream a short distance toward the extremity of a straight embankment or dike which is carried out from the adjoining shore. At the time this power was examined the mill was not running, the property having been purchased by the Hudson River Water Power & Paper Company with the design of repairing it and engaging here, as well as at the larger privilege below, in the manufacture of paper.

Power at Stillwater.—At this locality, 3 miles or so above Mechanicsville, the river-bed is composed of slate ledges running in a direction a little east of north and dipping sharply to the eastward. The west bank is rocky and of good height, while on the east side is a rather low meadow. The Hoosac river empties opposite Stillwater, but below the dam. The latter is a log structure, about 6 feet high, forming an irregular line across the river, presenting an angle up stream. It is nearly 50 years old, and though of course it has been repaired at times, the original structure still stands and serves its purpose tolerably well. A great deal of water leaks through, but there being always an abundance at the mills the loss is not felt, though roughly estimated to equal the amount used in manufacturing. The bulkhead is at the west end of the dam, and is of timber, with 13 gates, each $8\frac{1}{2}$ feet wide. Each gate has two upright wooden posts with iron racks firmly attached to it, and is worked by hand-power. A short side canal, 10 or 15 feet wide, opens out from the pond 100 feet above the bulkhead and connects with the main canal, but is itself without any bulkhead. The larger canal follows down the river-bank for about a third of a mile and is 100 feet wide. It has the natural river-bank on the inshore side, and is built out into the stream, being sustained on the outer side by a masonry wall 11 feet high, 7 feet wide at the base and 5 feet wide at the top. With one important exception the mills are built out over the canal, being supported on stone piers. The wheel-pits are all built on the outside of the river-wall. One mill, as noticed, is located on the inshore side of the canal, and connects with its water-wheel by a line shaft.

Reckoned from the crest of the dam the fall at the end of the race is about $7\frac{3}{4}$ feet, and is perhaps 1 foot less near the dam. The privilege is owned by Mr. John B. Newland, of Stillwater, who estimates the power in use as follows:

1. John B. Newland, grist-mill, 60 horse-power.
2. Knitting-mill (hosiery), owned by John B. Newland, but operated by E. B. Skinner & Co., 80 hands employed, 70 horse-power used.
3. Mosher, Judd & Co., paper-mill, 15 hands, 100 horse-power.
4. D. & W. Pemble's straw-board paper-mill, 6 hands, 40 horse-power.
5. R. & H. Newland's knitting-mill (hosiery), 80 hands, 40 horse-power.
6. Denison & Co.'s knitting-mill (hosiery), 60 hands, 40 horse-power.

In all about 250 hands are employed in the mills, and, approximately, 350 horse-power of water is in use. No curtailment of power has ever been necessary because of low water. On one remarkable occasion the mills were stopped by backwater due to a heavy ice-jam, but serious trouble of this sort has been experienced only twice in a great many years. Whenever ice runs over the dam there is sufficient depth of water to carry it clear of the crest, and the structure has never suffered any injury worth mentioning from this source. Ice that forms in the pond usually rots before running out, and such as comes down from above is well broken up against the piers of a road bridge a short distance up stream, and by four crib-work ice-breakers. As we have seen, the river is subject to heavy freshets, and a depth of 5 feet on the dam is not uncommon; in an extreme case a depth of 7 feet has been

observed. During spring freshets the effective head is reduced perhaps 2 feet, but the trouble lasts not over a week; the rapids below the dam carry off the water readily and the mills are never forced to stop.

In disposing of the power, Mr. Newland sells outright the sites and rights to use certain amounts of water. The water is sold in inches, an inch being the amount passing through an opening one inch square under the head actually obtained by the mill. In practice no special measurement is made, but the amount of water used is assumed from the wheel ratings. In the deeds a reservation is made that in case of a scarcity of water the grist-mill shall first be supplied; but in view of the abundance of water it is evident that such a reservation is practically no disadvantage to the other mills. For the purpose of meeting the expense of necessary repairs on the dam and bulkhead the power is nominally divided into 25 equal parts; each privilege is estimated at a certain number of twenty-fifths, and pays a proportionate share of the expenses.

Seven mill-sites with power are still held for sale. Six of these have each a river frontage of from 75 to 100 feet with a depth of 125 feet, and one has a much larger surface. Freighting is mainly done by canal when that is open, but at other times by team to Mechanicsville. The Boston, Hoosac Tunnel, and Western railroad runs through Stillwater, but is a mile away from the mills. The Delaware and Hudson Canal Company has a line of railroad graded through the village, and in fact to Schuylerville, but the enterprise has not advanced beyond the point of grading the line.

Estimated power of the Hudson river at Stillwater.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*	*7¾ feet fall.*	
Low water, dry year	9	12	10½	8	39½	3,700	580	65.89	460	510	350
Low water, average year							650	73.84	520	570	
Available 10 months, average year							1,100	124.96	870	970	

Unimproved power below the Saratoga dam.—Above Stillwater the river becomes very flat, and smooth water extends from the dam a dozen miles or more, nearly to the Saratoga dam. In this distance the river valley is generally wide and rather flat, with a gradual rise to distant hills, but within 3 miles of Schuylerville the adjoining country becomes somewhat more broken. Fewer islands are to be seen than between Stillwater and Troy, and the immediate course of the river is bordered by meadows which are frequently overflowed in places. At Schuylerville bridge the river is divided by an island into two channels, one about 500 and the other 250 or 275 feet in width.

Beginning a mile or so above Schuylerville there are one or two riffles, and a third of a mile below the Saratoga dam there is an important fall. It occurs immediately above what is known as "Willis' eddy", and by pocket-level was found to be about 8 feet in 200 feet, from the head to the foot of the falls. Farther up the river-bed displays considerable bare rock at low water, but there is no more fall of consequence before reaching Thompson's mill. There is apparently a foot or two of fall in low water immediately below the mill-wheels, but it would probably disappear in a fair stage of river.

The privilege here described is owned by Mr. Lemon Thompson. The river-bed at the falls is made up of outcropping ledges of slate-rock, the greater portion exposed in low water. Opposite the main fall both banks are rocky and of good height. The east bank was examined in particular, and was found to be composed of slate-rock to a height of about 8 feet above low-water level in the pool at the head of the falls, and above that a gravelly clay for 12 or 15 feet. The power might be developed here in either of three ways. The privilege might easily be combined with that at the Saratoga dam by bringing a race down the east bank, and would give a fall at low water of at least 17 feet. If improved independently, probably not more than the 8 feet (assuming that result correctly obtained) descent at the falls could be utilized. A mill would naturally be located on the east bank on a point formed by a cove or eddy below the falls. A dam of the full height could easily be built near that place, but the better way of improving the privilege separately would probably be to build a low dam on the rocks at or near the head of the falls, and construct a canal for the remaining short distance to their foot next the east bank. A dam running only part way across the river would undoubtedly command nearly the entire low-water flow.

Estimate of power at Thompson's privilege, below the Saratoga dam.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	*17 ft. fall.(a)*
Low water, dry year	9	12	10½	8	39½	2,904	210	23.86	190	410
Low water, average year							280	31.81	250	540
Available 10 months, average year							560	63.62	510	1,080

a Assuming the privilege at the Saratoga dam to be combined with that below.

Power at the Saratoga dam.—The Champlain canal crosses the Hudson in the pool of this dam, and is also fed here for the distance thence to Waterford. The immediate valley in the vicinity is three-quarters of a mile or a mile in width, and is a well-settled, cultivated farming district. The dam is owned by the state, and the present structure was completed in 1873 or thereabout. It is in two sections, forming an angle of something over 100 degrees, with the vertex up stream; it is of stone, the face having a small batter, and rests throughout on ledge rock. The dimensions are said to be: Height, 8 feet; width at top, from 7 to 9 feet, and at base about 12 feet. The abutments are of rock-faced ashlar, and the face of the dam appears to be of the same, though it is mostly concealed from view by a sloping crib-work apron projecting some 15 feet down stream.

At the east end of the dam a short race, 50 or 60 feet wide, carries water to the saw-mill of Lemon Thompson, owner of the surplus power. This mill is located in the town of Greenwich, and about 2 miles by road above Schuylerville. The fall obtained is 9 feet; 23 wheels are run, ranging from 2 to 60 horse-power each, but many of them are of old pattern and their effective horse-power is not easily estimated. Twelve of the wheels, each 48 inches in diameter, run a Monitor "slabber" and 2 gang-saws. It was estimated that for the year 1882 the mill would have sawed about 12,000,000 feet of lumber, an amount somewhat above the average. The logs are floated down the Hudson, and this is the last mill at which they are sawed. The timber obtained is about in the proportion of spruce 4, hemlock 2, pine 1, and smaller amounts of white and yellow cedar. The mill does not run while the river is frozen, but always has sufficient water during the sawing season. For the two years previous to the fall of 1882 it was stated that water had wasted more or less every day over the dam, excepting a single day in each year. Eighteen-inch flash-boards are kept on the dam. During the lowest stage of river the pond fills at night, and there is a waste on the dam till the next afternoon, and even then the water-surface often can not be drawn down below the crest.

Power at Fort Miller.—With 18-inch flash-boards on the Saratoga dam and a fair stage of river, slack-water extends entirely to the Fort Miller privilege. There the river bed and banks are rocky and the stream is full of outcropping ledges. A log dam runs in an irregular line across the river, varying in height from 2 to 9 feet according to its position on the ledges; it is about 700 feet long, and probably 15 or 16 feet wide at the base where of full height. The state is said formerly to have had a much higher dam here, but it was abandoned and the power utilized by private parties. The farmers, however, whose land adjoined the river above and had been submerged by the slack-water from the dam, though of course they had been paid for the land thus flowed, now claimed that it should revert to them, and coming down the river in force they cut away the old dam.

On the west side of the river a low wing-dam diverts the overflow from the main structure to a small mill on the adjacent bank, not in operation. The power at the west end of the main dam is owned by Mrs. Mary C. Harris, of Northumberland, and is nearly or entirely idle. On the Fort Miller side three-eighths of the power (three-eighths of one-half the entire power of the river at this fall) is owned by the heirs of Hosea Nichols, deceased, of Fort Miller; a small saw-mill belongs to the same estate, but is not running. The remaining five-eighths of the power is owned by Wagman, Thorpe, & Co., manufacturers of hanging-papers from straw- and paper-stock. They have also a 4-run grist-mill on the privilege, operated by A. T. Pack. The fall obtained at the paper-mill is between 10 and 11 feet. The wheels have a total rated capacity of about 200 horse-power, of which from 130 to 150 is in actual use. Six 400-pound rag engines are run, and one 68-inch cylinder machine, the capacity of the mill being stated at 3 tons of finished goods per day.

The booms and piers in the river below are said to obstruct the passage of running ice, thus forming jams and causing backwater at Fort Miller. One of the most serious troubles, however, is from anchor-ice, which is thought to be aggravated by the shallowness of the pond. This form of ice is seldom observed here except in windy weather. It rises with the sun and floats, often in large masses, on the surface of the water. It freezes readily to any surface with which it comes in contact, and sometimes collects to a thickness of 1 or 2 feet on the dam and backs up the river. It hinders chiefly, though, by getting into the water-wheels and stopping them.

Estimate of power at Fort Miller.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*10 feet fall.*	*11 feet fall.*	
Low water, dry year	9	12	10½	8	39½	2,881	300	34.08	340	370	250±
Low water, average year							370	42.03	420	460	
Available 10 months, average year							650	73.84	740	810	

Shortly above Fort Miller the Adirondacks come plainly into view to the westward from the carriage-road through the valley, while the intervening country stretches out only slightly hilly. The banks of the river are of moderate height, and are succeeded by meadow-land. The Fort Miller dam causes slack-water for about 2 miles

up stream at low water; there is then an unimportant shoal known as "Crocker's rift", and some 2 miles farther up another even less noticeable. With a fair stage of river there would probably be continuous smooth water to Fort Edward.

Power at Fort Edward.—At this locality the river-bed is rocky, and at low water, rapids with slight descent extend half a mile or more below the dam. The latter was built by the state, probably 40 or 50 years ago, and from the pool a feeder formerly ran to the Champlain canal. On the establishment of the Glens Falls feeder the dam at Fort Edward was cut down a number of feet and abandoned by the state. It is a log structure, not filled in with stone, and presents a wretched appearance. The decay of the timber has permitted it to sink at various points, although it has been patched up, and the face has bulged out so as to present a very irregular surface. The abutments are of crib-work. This dam is about 665 feet long between abutments and 16 feet high. The mills are located on the north bank. The hydraulic canal is 1,400 feet long and averages about 40 feet in width. A separate flume 460 feet long conveys water to the Fort Edward blast-furnace. Power is further utilized here in the saw-mills of Messrs. Tefft, Hinckley, & Co. and Messrs. Bradley & Underwood, and by several other concerns of moderate size, engaged in the manufacture of paper, pottery and stoneware, flour, and machinery. In 1880 a total of about 880 horse-power of wheels, not including those of the blast-furnace, was returned as in use under a fall of about 8 feet. The estimated amount of logs sawed annually at the two mills mentioned is 30,000,000 feet, and consists of pine, hemlock, and spruce, which is cut into boards, planks, and joists, and a few shingles. Bradley & Underwood also own the power at the south end of the dam, though none is utilized there.

The Fort Edward Manufacturing Company originally purchased this privilege, and then sold the various mill-sites and rights to water to the mill-owners. The blast-furnace, Osgood & Son's machine-shop, and Durghee & Son's grist-mill have a priority of right to water in case of a short supply. For the purpose of keeping the hydraulic works in order and repair the manufacturers are associated as "The Fort Edward Dam Company". For about three months in the year there is a scarcity of water and the greater part of the works have to be shut down. There appears to be no system of management worthy the name in connection with this privilege. No measurement is made of the water used, and disputes are of frequent occurrence.

Power at Sandy Hill.—Sandy Hill is 2½ or 3 miles above Fort Edward, and is situated at the point where the Hudson suddenly changes its general course from the east to the south. There are two water-privileges, the lower known as Baker's falls and used mainly by paper-mills, while the upper is occupied by saw-mills. The country surrounding Baker's falls is comparatively level, but the river appears to have cut its way down below the general level, and descends abruptly over massive ledges of black slate-rock. This slate is described as very hard when covered by water or earth, but upon exposure to the air it soon crumbles and forms a clayey soil.

The dam runs across at the head of the falls, and thence to the pool below, a distance of only 600 or 800 feet, there is a descent of 55 feet. The river then continues for some distance in a rocky gorge, the bank rising on the left precipitately to a height of probably 75 feet. At low water there are slight rapids below the falls, but they are covered, in a fair stage of river, by slack-water from the Fort Edward dam. The dam at the head of Baker's falls is 650 or 700 feet long, and varies in height from 3 to 14 feet, according to the surface of the rock on which it is founded. It is a log structure bolted to the river-bed, and with the logs also bolted together at their intersections. Opposite the falls as well as below, the banks are precipitous and rocky. The mills are on the left bank, and receive water through a race from 600 to 700 feet long. For about 200 feet before reaching the first mill the race is 25 or 30 feet wide, and is formed between the natural rock-wall on one side and a river-wall on the other. This latter averages 14 feet in height and is 4 feet wide on top; it is provided with an overflow to the river 60 feet long, beneath which the outer surface of the wall is faced with timber. The race ranges from 14 feet in depth near the bulkhead to 11 feet at the farther extremity. Toward the end, on the outer side of a bend, there is a gate 8 feet wide extending the whole depth of the race. By opening this gate a very strong current can be obtained and the race easily flushed clear of leaves, sawdust and other refuse, and ice. In this manner an amount of work is performed in a very short time which would otherwise require days.

The bulkhead is of timber, with seven gates, each 8 feet wide. The gate-posts are of white oak, and are 8 by 18 inches in cross-section. Each gate is provided with two vertical iron racks into which the cogs upon a horizontal shaft engage; the shaft is revolved by levers, and in turn acts to raise or lower the gates. The water is used in two falls. There is but one continuous race—the upper level—and after having been used from that the water is conveyed to the lower-level wheels by each mill independently. The fall from the upper level is 31 or 32 feet, and from the lower from 22 to 24 feet. Allen Brothers' mill, the uppermost on the race, employs only the upper fall of 31 feet, but the entire fall of 55 feet will be gained by sinking the wheel-pit and tunneling thence down stream.

The users of water-power here in the fall of 1882 were Allen Brothers, manufacturers of wall-paper; Wait & Son, wall-paper; Howland & Co., manila paper; and the Sandy Hill Iron & Brass Works, manufacturers of paper-mill machinery, turbines, and various other machine work. Water is owned in square inches, nominally under 31 feet head, but practically under the full head, since each party is recognized as having a right to the full head if desired. Allen Brothers own 620 square inches of water; Wait & Son own one-eighth of one-half the flow of the river, and actually use from 250 to 300 square inches; Howland & Co., 550 square inches; and the Iron & Brass Works, 25 square inches. The total rated capacity of wheels on this privilege, October 27, 1882, was 1,847 horse-power. The supply of water is

sufficient for the works now established, even in a low stage, but there is no surplus at such times, and in the month last mentioned the entire volume of the stream was part of the time in use. The water comes down very irregularly, being affected by the control exercised over it at the mills farther up stream. Each firm owns to the center of the river, and beyond that limit Howland & Co. and J. W. Wait are proprietors to high-water mark on the opposite bank; these gentlemen also own the balance of the power on the left bank not otherwise previously accounted for.

In Revolutionary times a grist-mill was the only utilizer of the power here. The first paper-mill was started in 1844. There has been a large growth in the manufacturing interest at Sandy Hill since that time, and the place is said now to rank second in freighting importance among the stations on the Rensselaer and Saratoga railroad. The production at Wait & Son's mill is 35 tons per week, and the estimated total production of the three paper-manufacturing concerns is about 165 tons per week.

The river is considered to reach its greatest height here usually in May. For a week or so there is considerable backwater below the falls, the extreme rise there being perhaps 20 feet.

The upper privilege at Sandy Hill is improved by a log dam which runs in a broken line across the river and projects down stream somewhat. It is about 600 feet long, 9 feet high, and is very old. The foundation is solid rock, and below the dam the overflowing water has evidently torn huge slabs from the river-bed and piled them up. The abutments of the dam are crib-work loaded with stone. On the right bank power is used in Monty & Shippy's saw-mill, having a capacity for sawing about 100,000 feet of lumber in the 24 hours, (*a*) and running 25 wheels with a combined rating of about 400 horse-power. On the left bank the privilege is owned by William H. Bloomingdale, and the power is employed by Richards & Bromley in their saw-mill. Although the fall from the top of the dam is about 9 feet, yet, owing to the pond being much of the time low, the average effective head obtained is estimated as low as 7 feet. There are 18 wheels in the mill, mainly cast-iron "rose" wheels, but their power could not be learned definitely. In a busy year the mill saws about 400,000 pieces, or say 4,000,000 feet of lumber.

For about two weeks during spring, high water prevents the work of getting logs and would render it dangerous to run the mill. The ordinary freshet depth on the dam is 5 or 6 feet, but in the spring of 1869 it was only 2 or 3 inches less than 9 feet. Ice is said almost invariably to rot in the ponds on this part of the river. It seldom goes over the dams except in a kind of slush, and sometimes can hardly be perceived at all.

Power at Glens Falls and vicinity.—The two privileges at Sandy Hill succeed each other closely, but between the upper one and Glens Falls another might be developed. It is located near the foot of the gorge through which the river runs after passing the mills at the latter village, and has an available fall of 15 feet, with firm rocky bed and banks for a dam, and good building-room. It is owned, including the adjoining land on both sides of the river, by the Morgan Lumber Company, of Glens Falls, and is reckoned as good for 500 horse-power at least nine months in the year. Though not on the market, this privilege could be purchased at a suitable price. The available power may be estimated as below:

Estimate of power at the Morgan Lumber Company's undeveloped privilege below Glens Falls.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*15 feet fall.*
Low water, dry year	9	12	10½	8	39½	2,716	160	18.18	270
Low water, average year							240	27.26	410
Available 10 months, average year							520	59.07	890

At Glens Falls we encounter the second great pitch in the river, amounting to about 40 feet from the top of the dam to the foot of the main falls. The Hudson here runs easterly, while the rock strata have a southerly dip of about 20 degrees. Down through these strata the stream has worn its way, forming below the falls a natural gorge with steep sides, though its form has been destroyed by extensive quarrying next the river. The gorge continues for from a third to a half-mile down stream, after which the banks become more gentle in slope. The feeder to the Champlain canal runs at no great distance from the river, on the north side, and the sheets of water which fall down into the river at various points from between the rock strata indicate a considerable leakage. Below the falls, at least, the original continuity of the strata on the opposite sides of the river is easily apparent. A vertical section shows the following materials: from 14 to 15 feet of sand, gravel, and other surface deposits, then 12 feet of inferior limestone, 14 feet of a nondescript stone called "buckwheat", 2 or 3 feet of gray marble, 12 feet of black marble, succeeded by lime-rock and building-stone. The black marble takes a fine polish, and on the north side of the river, Finch, Pruyn, & Co. have an establishment for working it. Limestone is quarried and burned on both banks, the Morgan Lime Company owning the works on the south side.

a Saw-mills in this section run night and day during the working season.

The lumber interests at Glens Falls are very extensive. Logs are cut from 20 to 100 miles northward on the upper waters of the Hudson and its tributaries and floated down. The Morgan Lumber Company has sawed as high as 35,000,000 feet of lumber in a single year. In 1881 the amount, including refuse, was 27,000,000, and for 1882 had reached about 21,000,000 feet on October 27. The logs are spruce, hemlock, and pine, in the order named as regards quantity. In busy times about 150 men are employed at this company's mills.

The dam is at the head of the falls, and is a timber crib-work built on solid rock. The intersections of the timbers are firmly bolted, and the whole structure is secured in a like manner to the foundation rock. The timbers are squared and so laid as to form a tight face and back, the top of the dam being also closed by planking. The dam is in three sections, two running diagonally, somewhat up stream, and the third closing the gap between them. The whole length is about 400 feet, while the height varies from 5½ to 6½ feet. Near the center is a sluice-way, 45 feet long, for logs; it is shod with iron straps, and is depressed below the main crest of the dam 24 inches for 10 feet of its length and 10 inches for the remaining 35 feet. The face and back of the dam are vertical, the back being from 2 to 2½ feet high; the top of the structure has a slope up stream, and is from 10 to 11 feet wide. The abutments and bulkheads are formed by timber and stone crib-work piers. There are no gates, properly so called, controlling the admission of water to the races, but each main race is divided by timber partition-walls into minor races so as to keep the logs separate for the different saws. On the north side of the river there are three of these divisions and on the south side five; still another race on the latter side is supplied with water by the overflow from the main dam, which is diverted to the race by a second low dam—a wing about 2 feet high running from the center of the stream to the south bank.

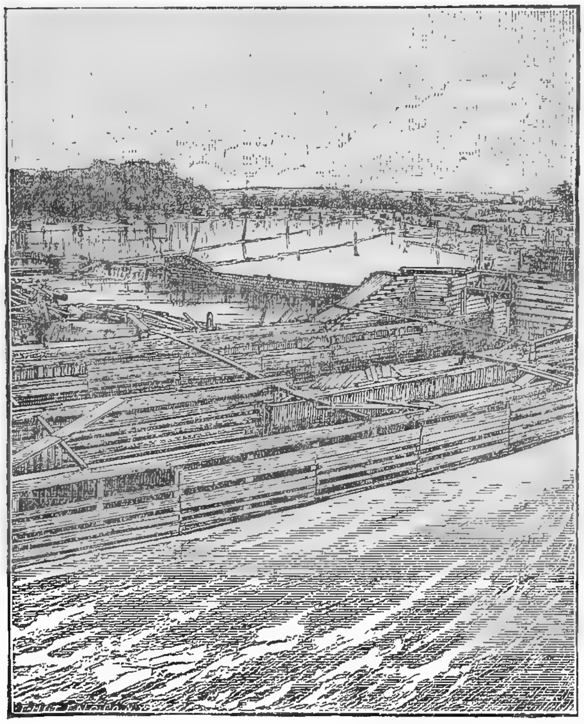

FIG. 3.—View of Hudson river at Glens Falls dam, showing booms and piers for holding logs.

The power on the south bank is owned in part by three different concerns, and is used in three separate and successive falls. The Morgan Lumber Company is the principal user. Its mills are shortly below the dam, and at them the water is first employed under a head of 15 feet, the tail-water then passing in a common race to its lower mill and to Lapham & Co.'s grist-mill. The latter firm has a right to sufficient water for 9 runs of stone; it uses about 9 feet head and operates 7 runs of stone, with water-wheels having a total rated capacity of from 200 to 250 horse-power. Tail-water from the grist-mill is discharged directly into the river. The Morgan Lumber Company's lower mill uses its share of water from this second level under 16 feet head. Of its tail-water, which forms a third level, part runs through a long open wooden flume down to the lime company's works, but the chief portion furnishes power for the Glens Falls Paper Mill Company, manufacturing printing-papers, with a production of 5 tons per day. The water is here used under a head of 11 or 12 feet and discharged into the river. The company owns water sufficient for 4 Fourdrinier machines, but prior to it the grist-mill is entitled to its supply, and the Morgan company to water for 4 gates.

On the north side of the river the power is all owned and the works are operated by Messrs. Finch, Pruyn, & Co. This firm has here a large saw-mill, a planing-mill, a grist-mill, marble works, and lime and marble quarries. At all of these except the quarries water-power is used, the aggregate amount being stated at 825 horse-power. At present the power on this side of the river is not thoroughly developed, some of the water being returned to the river before it has been utilized through the entire fall. The saw-mill, a short distance below the dam, uses water first under a head of 12 or 14 feet, and discharges directly into the river. A separate flume leads to the 3-run grist-mill, which has about 14 feet fall. Its tail-water is conveyed through another flume to the marble works, where it is used and discharged into the river.

For two or three months in the year the supply of water is insufficient for the needs of manufacturing at Glens Falls, although the mills can run more or less even during that time. The aggregate of power in use on both sides of the river can not be stated with any accuracy, but probably amounts to from 2,000 to 2,100 horse-power.

The next power to be noticed is about 1 mile above the main village of Glens Falls, at the state feeder-dam. There are some riffles before reaching it, but the fall is said to be too slight to have any importance. The dam is straight, 618 feet long between abutments, and is a crib-work filled with stone, with a sloping apron of the same construction, the whole planked over; it rests on rock, and was built about 1875. A sluice-way in the center provides for running over logs. The abutments are rock-faced masonry. At the north end of the dam is a double lock, one side for boats and the other to serve as a water-way only. The Glens Falls feeder runs from this point to the Champlain canal and carries off a large amount of water, there being a rapid current through the lock. The

surplus power at this end of the dam is owned by Van Deusen & Freeman, and is used by them in a saw-mill running 25 or 30 water-wheels, power unknown, and sawing an average of from 10,000,000 to 11,000,000 feet of lumber per year. The mill is close to the dam and has a fall of 14 or 14½ feet. On the south side the power is owned and used in large saw-mills by Finch, Pruyn, & Co. and A. Sherman. The state maintains 20-inch brackets on the dam, and will not permit the mills to draw down the pond more than half-way on these brackets. There is more or less shortage of water at the mills during four months in the year.

Glens Falls to Palmer falls.—Above the feeder-dam slack-water continues for some 6 miles, the greater part of which is included in a long bend, or "ox-bow", and here is the great "Hudson River boom", where immense numbers of logs are held for the use of the mills on the river below. The surrounding country is level and sandy as far as the mountains, several miles west of Glens Falls.

Immediately succeeding the slack-water formed by the feeder-dam, Messrs. Van Deusen and Sherman own an unimproved privilege which they hold for sale. It is about 4 miles from the railroad, offers a pebbly bed for a dam and has a large tract of level land adjacent. The privilege is reckoned at from 20 to 30 feet fall according to the height of dam. With a dam 6 feet high and a race three-quarters of a mile long it is stated that a fall of 22 feet can be obtained. The corresponding power may be estimated as below:

Estimate of power at Van Deusen and Sherman's unimproved privilege above the "Hudson River boom".

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power			
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	*22 feet fall.*	*30 feet fall.*
Low water, dry year							260	29.54	590	650	890
Low water, average year	9	12	10½	8	39½	2,704	340	38.62	770	850	1,160
Available 10 months, average year							620	70.43	1,410	1,550	2,110

Upon following the course of the river into the mountains there is found to be a continuous rapid for some miles; this is succeeded by quiet water for half a mile or so, after which there are rapids at short intervals. Through the mountains, before reaching Palmer falls, so far as there was opportunity to examine, the bed was found to be composed of gravel and bowlders, without displaying much ledge rock. The banks are rocky in places, but to a large extent are of sand with bowlders intermixed. The valley is comparatively narrow, and is inclosed by high hills which frequently rise abruptly from the stream, especially on the right. The valley is sparsely settled, without any, railroad, has apparently small value for farming, and is not suited to the location of large villages.

Power at Palmer falls.—The privilege at that place is owned by the Palmer Falls Water Power Company (not incorporated), J. S. Alexander being the local representative of the company's interests. The power is but partially developed, and apparently no special effort has been made for its thorough improvement. It is a magnificent privilege, but appears difficult and expensive to utilize completely. Past Hadley, at the mouth of the Sacondaga, the Hudson runs southerly, and soon enters a more open country than it has previously traversed. A few miles below Hadley it turns and runs easterly. From Rockwell falls, just above the Sacondaga, down to Jessup's landing there is said to be smooth water, which was observed to be the case wherever the river was visible from the carriage-road. Shortly below the ferry at Jessup's landing rapids begin, and the stream enters a rocky gorge in the hills. In a distance which was judged to be less than a mile there was stated to be a descent of from 105 to 110 feet, and 80 feet of this is concentrated within a few hundred feet at Palmer falls.(*a*) The scenery at that point is rugged and grand; the river is confined between precipitous ledges, its bed is solid rock, and its waters pass down in a final plunge of nearly 30 feet into a pool below. Quiet water then succeeds for perhaps half a mile down stream, after which the character of the river is as has already been described.

The steep rocky sides between which the river flows above the principal falls render its improvement there impracticable. The last 80 feet, including those falls, has been partially improved, however, though only 30 feet is actually utilized. At the head of the main falls a log dam extends across the river in an irregular line, following some distance parallel to the right bank so as to give sufficient overflow. It is a crib-work structure with vertical face, and on top a short slope each way from the crest. The roll-way is 600 feet long, with a height ranging from 10 to over 30 feet, but averaging about 25 feet. It abuts against the rocky wall of the stream on the left, and on the right has a masonry abutment. Water is admitted to the race through a timber bulkhead measuring from 40 to 50 feet across and having 4 gates. From the bulkhead this race is continued some 300 feet, being confined on the river side by a masonry wall averaging 25 feet in height and 4½ or 5 feet in width on top, while on the shore side is the natural wall of rock. This race constitutes the upper level, which has been improved by the Hudson River Pulp & Paper Company with the view of locating new mills between it and the lower level, to be described. A dispute between this company and the water-power company, however, has brought operations

a The total fall from Jessup's landing to the top of the feeder-dam was reported to be 200 feet, but the accuracy of the statement can not be vouched for. The fall is probably at least the amount reported.

to a stand-still, after an expenditure by the former of about $35,000 for dam, race, and connected work. The level now terminates in a timber bulkhead and on one side a weir 80 feet long, over which water falls to the lower level.

Any overflow from the dam and any leakage through it are at low water diverted entirely to the lower level by a natural barrier of rock which extends across the course of the stream a short distance below the dam. The water enters this level through a timber bulkhead and passes on to the mills, being sustained on the river side by a wall of crib-work. The fall from the upper level to the lower is about 50 feet, and thence to the river 30 feet. The only use of power here is made by the company already mentioned, manufacturer of news- and hanging-papers and refined spruce and poplar wood-pulp. The production is 10 tons of paper and 8 tons, dry weight, of wood-pulp per day. All the pulp is worked up here in the manufacture of paper. Water for power is taken entirely from the second level, and used under a head ranging from 20 to 30 feet on the different wheels, but estimated as averaging about 27 feet. The total horse-power of wheels in place is from 1,450 to 1,500.

There has been manufacturing of some kind at this privilege for forty or fifty years, and power was formerly used by a small woolen-mill. The paper-mill has been located here since about 1870. With the present head in use it at times requires all the flow of the river. This was the case in the summer of 1882, and even toward the end of October in that year.

Estimate of power at Palmer falls.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.				Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	30 feet fall.	50 feet fall.	80 feet fall.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*					
Low water, dry year	9	12	11	8	40	2,650	250	28.40	850	1,420	2,270	1,450–1,500
Low water, average year							330	37.49	1,120	1,870	3,000	
Available 10 months, average year							600	68.16	2,040	3,410	5,450	

The Hudson at Hadley and above.—There is quiet water, as has been said, from Jessup's landing to Hadley. At the latter point, immediately above the mouth of the Sacondaga river, is the last improved power, so far as was learned, on the river. It is at the foot of what were known as Rockwell falls, and is occupied by the Rockwell Falls Fiber Company, manufacturer, by chemical process, of wood-pulp from pine, spruce, bass, and poplar, with a production of 5 tons per day. The dam is a log and stone crib-work about 140 feet long and 13 feet high, with a sloping apron; including the apron, the width of the structure at the base is 40 feet. It was built in 1881 and cost $5,000. Wheels of an aggregate of 120 horse-power are in use under 13 feet fall, and there is always much more than enough water for running them. The mill is on the Hadley side, and just across the stream is the village of Luzerne.

Slack-water from the dam just described extends but a short distance, and then there are short falls with rocky bed and banks. Thence 14 miles to Thurman there is smooth water nearly all the way, with very few riffles even. The bed is gravelly, while the immediate banks are in the main sandy, and in places successive terraces are seen rising from the stream. As we ascend above Hadley the immediate banks become lower, and the river is frequently divided by islands. The valley contracts, and is hemmed in by high rocky hills, so denuded of timber as to present a bare and forbidding appearance. It is seldom more than a quarter or a third of a mile wide between the bases of the hills, and frequently the distance diminishes to a few hundred feet. There are but few habitations, and the land in the valley appears practically valueless for farming.

Above Thurman the fall is more rapid. There are riffles at short intervals, and at length the rate of descent becomes uniformly swift. The bed and banks also change their character; the former is now covered with bowlders, and even displays ledges at intervals, while the banks are also rocky much of the way. At North Creek bridge the Hudson is 250 feet wide, with a firm gravelly bed and a good current. It is there subject to sudden and heavy freshets, and at such times overflows the adjoining flats, though they do not reach far back from its course. The surrounding hills were once heavily clothed with timber, but now display for the most part naked masses of rock. At present the cutting of timber is mainly 30 miles or more to the northward from North Creek. The Adirondack Company's railroad has not been extended above that village, and the examination of the river ceased there. The stream was described as retaining, for a long way above, the same general features that have already been noticed as characterizing its course north from Thurman.

Summary of water-privileges on the Hudson river.

Locality.	Manufacture.	Drainage area.	Fall.	Estimated theoretical horse-power. (a) Low water, dry year.	Low water, average year.	Available 10 months, average year.	Effective horse-power of wheels in use.	Remarks.
		Sq. miles.	Feet.					
From lake Tear-of-the-Clouds to the mouth of North creek.			3,341					Fall entirely unimproved. River not accessible by railroad.
Below the mouth of North creek.		753		b 7.95	b 11.36	b 19.31		River about 250 feet wide, with good current and gravelly bed.
From North creek to the crest of the Rockwell Falls dam.			431					River followed by railroad. Narrow rocky valley and very little settlement. No use of power.
Hadley (Rockwell falls)	Chemical wood-pulp	1,598	13	240	300	590	120	Production 5 tons per day.
Palmer falls	News- and hanging-papers and wood-pulp.	2,650	80	2,270	3,000	5,450	1,450–1,500	Manufacturing carried on by the Hudson River Pulp & Paper Company. Privilege owned by the Palmer Falls Water Power Company. Only 30 feet fall actually in use.
Four miles west of Glens Falls.	Unimproved	2,704	20–30	590–890	770–1,160	1,410–2,110		Privilege owned by Van Deusen and Sherman. It is stated that a dam 6 feet high and a race three-quarters of a mile long will give 22 feet fall. Pebbly bed for dam, and abundant building-room.
State feeder-dam	Lumber		14				(c)	Dam owned by the state. Surplus power used by large saw-mills on both sides of the river.
Glens Falls	Lumber, paper, flour, marble, and lime.	2,716	40–43				2,000–2,100	Scarcity of water during two or three months in the year.
Do	Unimproved		15	270	410	890		Privilege owned by the Morgan Lumber Company. Rocky bed and banks, and good building-site.
Sandy Hill (upper privilege).	Lumber	2,724	7–9				900(?)	
Sandy Hill (Baker's falls)	Wall-paper, manila paper, and machinery.		55				1,847	Estimated production of paper, 165 tons per week. Full power of the privilege not yet developed.
Fort Edward	Lumber, iron, pottery, stoneware, paper, and flour.	2,744	(d)				880±	Two mills saw annually about 30,000,000 feet of lumber.
Total from the mouth of the Sacondaga river to Fort Edward.			418					From 200 to 220 feet may be regarded as developed for use, though not all of this amount is actually employed.
Fort Miller	Hanging-paper, mainly	2,881	11	370	460	810	250±	Small power also used by a grist-mill.
Saratoga dam	Lumber	2,904	9				160(?)	State feeder-dam, and pool also used for crossing of Champlain canal. Surplus power owned by Lemon Thompson. About 12,000,000 feet of lumber estimated to be sawed at mill in 1882.
Short distance below the Saratoga dam.	Unimproved		Say 8	190	250	510		Owned by Lemon Thompson. Favorable for improvement.
Stillwater	Hosiery, paper, and flour.	3,700	7¾	510	570	970	350	Power owned by John B. Newland. Several good sites with power yet for sale.
Mechanicsville (Howland's dam).	Manufacture will be paper.		8					Now owned by Hudson River Water Power & Paper Company.
Mechanicsville (main privilege).	Manufacture will be paper and wood-pulp.	4,476	16	1,640	1,820	2,910		Newly developed. See description. Twenty feet fall available by raising dam.
From Mechanicsville to Troy.	Unimproved		e 30±	b 102.24	b 113.60	b 181.76		It is estimated that one good privilege with 18 feet fall can be established.
Troy and Green Island	Paper, sashes and blinds, flour, and stoves.	8,034	10				1,293+	Power on east side represented by Troy Hydraulic Company. On west side leased by heirs of G. M. Tibbits. State owns dam, and only surplus water can be used.

a Based upon average flow for the 24 hours. *b* Per foot fall. *c* Amount uncertain.
d Dam 16 feet high, but head actually in use stated to average only about 8 feet. *e* Total fall.

TRIBUTARIES OF THE HUDSON RIVER.

In view of the large number of tributary streams included within the Hudson River basin and having more or less value for power, it was impracticable to attempt more than to gain a reasonably full description of some of the more important of them, and personal examinations were confined to the larger streams emptying above Troy. A great many streams were thus omitted which are suited to powers of moderate size, and which would in some instances doubtless support very considerable manufacturing interests. The aggregate of power in use on these is also large, but mainly distributed among small mills, and sufficient knowledge upon that point can probably be gained from the tables of utilized powers.

List of the principal tributaries of the Hudson river.

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Indian river	124	Catskill creek	419
Schroon river	556	Jansen's kill	239
Sacondaga river	1,028	Esopus creek	438
Batten kill	457	Rondout creek	1,252
Fish creek	253	Wappinger creek	183
Hoosac river	710	Fishkill creek	189
Mohawk river	3,493	Murderer's creek	165
Norman's kill	161	Croton river	368
Kinderhook creek	534		

THE MOHAWK RIVER.

This important river has its sources in western New York state, near the boundary between Lewis and Oneida counties, about 40 miles from the eastern end of lake Ontario and 15 or 20 miles north of the city of Rome. It runs southerly to that city, and then takes a course somewhat south of east across the state, passing through the counties of Oneida, Herkimer, Montgomery, Schenectady, and forming the boundary between those of Albany and Saratoga, finally emptying into the Hudson a little above Troy. It has a drainage area of 3,493 square miles, a length by actual course of from 140 to 145 miles, and receives successively below its source, as principal tributaries, Oriskany, West Canada, East Canada, and Schoharie creeks, the first and last of these from the south, while the Canada creeks come from the Adirondack mountains to the northward. From Rome to its mouth the Mokawk is closely followed by the Erie canal and the New York Central and Hudson River railroad. The valley has thus become a great thoroughfare between the West and the East, and in it a line of prosperous towns has sprung up, the most important places, in order from the head, being Rome, with 12,000 inhabitants; Whitesborough, 1,400; Utica, 34,000; Frankfort, 1,100; Ilion, 3,700; Mohawk, 1,400; Herkimer, 2,400; Little Falls, 6,900; Saint Johnsville, 1,100; Fort Plain, 2,400; Canajoharie, 2,000; Fultonville, 900; Fonda, 900; Amsterdam, 9,500; Port Jackson, 700; Schenectady, 13,700; Cohoes, 19,400; and Waterford, 1,800.

The immediate valley of the Mohawk is broad and open, frequently 1 or 2 miles in width, and is made up of level meadows from which there is a rise, usually gradual but sometimes abrupt, to the summits of high hills which attain altitudes of several hundred feet above the stream. The valley is not, however, throughout as open as has been described; toward the mouth it becomes at points quite contracted and the meadows disappear; at other localities rocky bluffs now and then approach the stream on one side or the other, and at Little Falls it cuts through a remarkable gorge, the rocky walls of which rise precipitously 500 or 600 feet. West of Rome the water-shed between the river basin we are considering and the section draining toward lake Ontario has an elevation above sea-level of only about 430 feet. This is said to constitute the lowest pass in the Appalachian system of mountains, and has been taken advantage of as a route for the Erie canal.

The highlands to the north of the river valley are succeeded by an elevated plateau having a general slope toward the river, and rising here and there in summits to elevations of from 2,500 to 3,000 feet above tide. Transparent lake, drained by the upper waters of West Canada creek, has an altitude of 2,187 feet above sea-level. The flats which border the river have a rich alluvial soil finely suited to the raising of grass, grains, and broom-corn; the more elevated lands are covered with a sandy and gravelly loam of fine quality, and there stock-raising and dairying are the principal industries. To the northward, where the Mohawk basin touches upon the Adirondacks, the primary formation is met with, and granite, gneiss, hornblende, and allied rocks prevail. These occasionally crop out also at localities farther south, as at "the Noses", bordering the river in Montgomery county, and at Little Falls. At Cohoes and other points along the lower river the bed and banks are composed of Hudson River shale and slate. In Montgomery county heavy masses of calciferous sandstone appear on the north side of the stream, and the Black River and Trenton limestones afford valuable quarries of building-stone. In Herkimer county the Utica slate is said to crop out on the summits of all the hills immediately north of the Mohawk.

Below Rome the fall in the river is in general small and quite uniform, being made up of long quiet reaches separated by slight riffles. At Little Falls the uniformity is broken and the river descends in successive falls a total of about 45 feet in 2,500. From Rome to the lower aqueduct, at Crescent, a distance of 110.7 miles, there is a fall of 269 feet, or an average of 2.43 feet per mile. Thence to the level of slack-water above the Troy dam there is a farther descent of 149.5 feet in 4.4 miles, but of this 104 feet is included within the magnificent improved power at Cohoes.

Table showing the fall in the Mohawk river.

Locality.	Distance from mouth of river.	Elevation of water-surface above mean sea-level.	Distance between points.	Fall between points.	Fall per mile between points.	Authority for elevation.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	
Rome above feeder-dam	115.1	430.5				Erie Canal profile. (*a*)
			3.0	12.1	4.03	
New York Central and Hudson River Railroad crossing 4 miles east of Rome.	112.1	418.4				New York Central and Hudson River Railroad profile. (*b*)
			17.0	25.1	1.48	
New York Central and Hudson River Railroad crossing 3 miles east of Utica.	95.1	393.3				Do.
			53.5	123.3	2.30	
Mouth of Schoharie creek	41.6	*c* 270.0				Do.
			22.4	56.3	2.51	
New York Central and Hudson River Railroad crossing at Schenectady.	19.2	213.7				Do.
			14.8	52.2	3.53	
Lower aqueduct	4.4	*c* 161.5				The Erie Canal profile gives water-surface in canal at aqueduct as 187.99 feet + mean low-tide at Albany.
			4.4	149.5	(*d*)	
Mouth of river	0.0	*c* 12.0				Estimated elevation of slack water above Troy dam at mouth of "North branch".

a The plane of reference for that profile is mean low-tide at Albany, which is 2.07 feet above mean sea-level.
b A large number of elevations on the lines of this railroad were kindly supplied by Mr. Charles H. Fisher, chief engineer.
c Approximate.
d Fall mainly concentrated at Cohoes.

For a large part of the year the Mohawk is comparatively steady in flow, but at times it becomes swollen to a violent flood, and in spring bears along heavy masses of running ice. In one freshet 20 years ago there is said to have been a depth of 12 feet of water on the Cohoes dam. When it is considered that this was upon a roll-way some 1,400 feet long, an idea is gained of the tremendous volume of water that must then have been pouring down the course of the stream. At the lower and upper aqueducts spring-freshet rises of 9 or 10 feet are not uncommon, and on the rifts at the former point the river is said to have risen many years ago to a level with the canal, or about 28½ feet. Such excessive rises seem to have been aggravated by ice-gorges, which even now often form below Schenectady, in the vicinity of Little Falls, and very likely at other localities, but which are less dangerous than formerly, as there are more obstructions in the form of piers and dams to break up the ice. The general clearing up of the country, the more extended cultivation of the soil, and the drainage of swamp-lands in the vicinity of Rome, have combined to produce, in general, greater fluctuations of flow than formerly characterized this river. Twelve hours after a rainfall in the center of the state its effect is usually visible at Cohoes.

At a number of points the Mohawk is drawn upon, either directly by dams across its course and connecting feeders, or indirectly by tapping its tributaries, to supply the Erie canal during the season of navigation. The draughts thus made vary somewhat from time to time, according to the amount of traffic passing over the canal and from other causes, but on the whole are tolerably uniform, and at several localities are quite large. How much of the water ultimately finds its way back into the river through one channel and another it is of course impossible to say. The extent of the demands made upon the Mohawk for canal purposes may be learned from the following statement, the data for which are taken from the *Annual Report of the State Engineer and Surveyor* for the year 1867:

Diversion of water to the Erie canal.

Source of supply.	Amount furnished per second.	Remarks.
	Cubic feet.	
Champlain canal and Mohawk river at Cohoes	110	Includes the amount coming down the Champlain canal, the balance being taken from the Mohawk.
Mohawk river at Rexford Flats	183	
Schoharie creek	113	Taken from the creek near its mouth and conveyed through a short feeder
Mohawk river at Rocky rift	177	4½ miles below Little Falls.
Mohawk river at Little Falls	211	Taken from the pool above the upper dam.
Ilion creek	13	
Oriskany creek	....	Dam near mouth, with short feeder. At Solsville, near the head of the creek, a diversion is made to the latter of a considerable amount of water from a series of reservoirs lying naturally within the basin of the Chenango river. A portion of their supply passes down to Utica via the Chenango canal, the receipt from which source is stated at 15 cubic feet per second; the remainder descends through Oriskany creek and is controlled by the dam above mentioned.
Butt's creek	23	2½ miles east of Rome.
Upper Mohawk river, and reservoirs in the Black River basin; supply received at Rome.	218	In the upper basin of Black river is a series of large reservoirs, the storage of which is conducted to Boonville, on the summit level of the Black River canal. One portion passes down that canal northward toward Carthage. A second portion descends southerly through the Black River canal to Rome, being re-enforced, 4 miles north of the city, from the Mohawk river, by means of the "Delta" feeder; the receipts of the Erie canal at Rome from this source are stated at 22 cubic feet per second. The third and remaining portion of the water descends through the channel of the Lansing kill and upper Mohawk to Rome, increased on the way by the natural drainage to the river, and is there controlled by a dam and feeder, supplying thus 196 cubic feet per second to the Erie canal.

WATER-POWERS.—Shortly before reaching the Hudson river the Mohawk divides into three principal channels, separated by islands, and by throwing dams across the minor passages which are formed by other and smaller

islands in the northern of the main channels, two very good water-privileges have been developed. The lower of these privileges is along what is known as "King's ditch", or "King's canal". A short timber dam runs out on the rocky bed of the river to a small island, and beyond it is continued in a second section to the large Haver island which divides the north and middle channels of the river. Water is admitted to the canal through a timber bulkhead about 45 feet long, and passes half a mile down the north bank of the river, supplying on its way the various mills which are between the canal and river. The fall obtained is 13 or 14 feet.

This privilege was developed some 50 years ago by Foster King, and rights have been sold off at various times since to the mill-owners. The whole power is nominally divided into twenty equal parts. Repairs are attended to by an association of the manufacturers called the King's Canal Company, and each share is assessed for its proportion of the resulting expenses. No system of measurement is maintained, however, to insure that each mill shall receive the proper amount of water. For about nine months in the year there is an abundant supply, but the remainder of the time there is more or less scarcity, usually in summer, but sometimes also in winter. The manufacturing at this privilege comprises stove-nuts, printing paper, stocks and dies, straw-board, flour, and machine work. There are seven different mills and shops, and in 1880 an aggregate of nearly 450 horse-power of wheels was in use.

The next power, a short distance above, is owned by Messrs. Himes & Vail, who run 10 sets of machinery in the manufacture of shirts and drawers. The privilege is a very old one, and was formerly occupied by a grist-mill and a satinet-mill. The extreme northerly channel of the Mohawk is here crossed by a timber dam resting on a ledge and running out to the high rocky bank of Mill island. It presents an angle up stream, has a vertical face, and is to be replaced by a new framed structure. Water is admitted through a wooden bulkhead and carried several hundred feet to the mill in an open wooden flume and a cylindrical wooden trunk, the latter of 3-inch pine, $5\frac{1}{2}$ feet inside diameter. The dam has a mean height of $6\frac{3}{4}$ feet, and rapids which extend below increase the head at the mills to 12 feet. One wheel of 50 and one of 80 horse-power are employed. Himes & Vail not only have enough water for their own use, but estimate a permanent surplus of 150 horse-power, which they would like to lease for manufacturing purposes. They state that for a desirable party they will erect a suitable building, leasing the room and power.

A short distance above the power just described is the third from the Hudson, formed by the state dam in the pool of which the Champlain canal crosses. The dam is a fine structure of stone, represented on a local map as 1,500 feet long; it has masonry abutments and a sloping apron of crib-work. Before this dam was built for canal purposes there were wing-dams here at which power was used, and the present privileges were received from the state in exchange for for rights surrendered. At the south end of the dam are the works of the Weed & Becker Ax Manufacturing Company, and at the north end, a little way along on the line of the canal, is the Munson Manufacturing Company's mill. This concern makes knit underwear, running 7 sets of machinery. It obtains 10 feet fall, and uses not over 90 horse-power from 3 water-wheels rated in the aggregate at 125 horse-power.

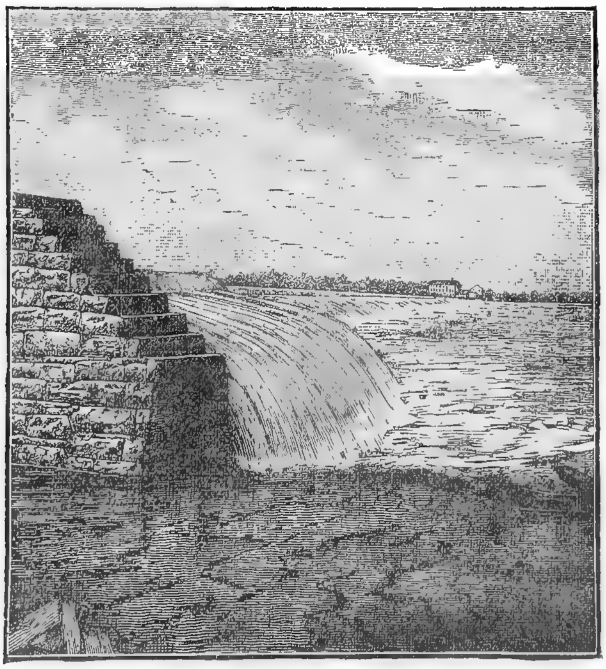

FIG. 5.—View of Cohoes Company's dam.

Power at Cohoes.—The Mohawk at this point runs in a rocky trough, the bottom and sides of which are composed of Hudson River slate and shale; the strata have a dip to the northwest, and in an artesian-well boring are said to have been found to a depth of 2,300 feet. The rock contains many pot-holes, some of great size. In preparing the foundations for one of the Harmony mills a very large pot-hole was encountered containing the bones of a mastodon, from which circumstance the mill came to be known as the Mastodon mill. The skeleton of the gigantic animal is now at the museum in Albany. The river falls rapidly past the city, descending, as nearly as can be ascertained, about 139 feet from the top of the Cohoes Company's dam to the level of slack-water from the Troy dam. Included in this are the "falls" proper, where the river suddenly pitches down a steep face of rock. In low water the volume of the stream passes around these falls, through the hydraulic canals, and there is only to be seen the dark and massive ledge, relieved by one or two silvery streaks where a little escaping water finds its way down.

Water is taken from the river about 3,700 feet above the great falls and nearly 9,000 feet above the state dam previously referred to. The first dam, a wooden structure, was erected in 1831, partially destroyed by ice in 1839, and repaired in the same year. A new dam, of wood, was also built in that year, about 50 feet below the first one, and served until 1865, when the present dam was built, immediately below and adjoining that of 1839, the two forming substantially one structure. The roll-way of this dam is 1,400 feet long, while the height averages about

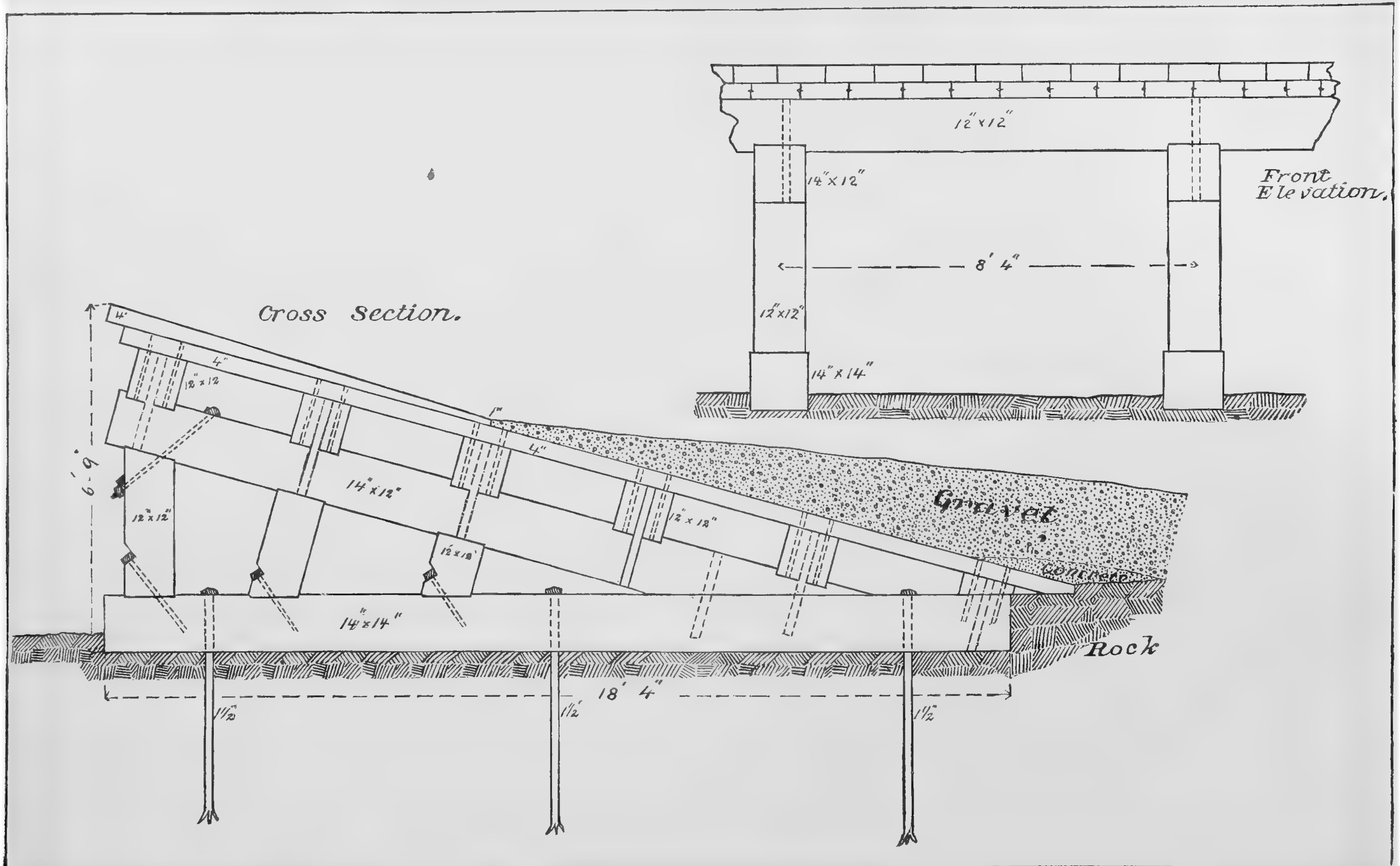

FIG. 4.—Deisgn for new dam for Messrs. Hines and Vail at Waterford.

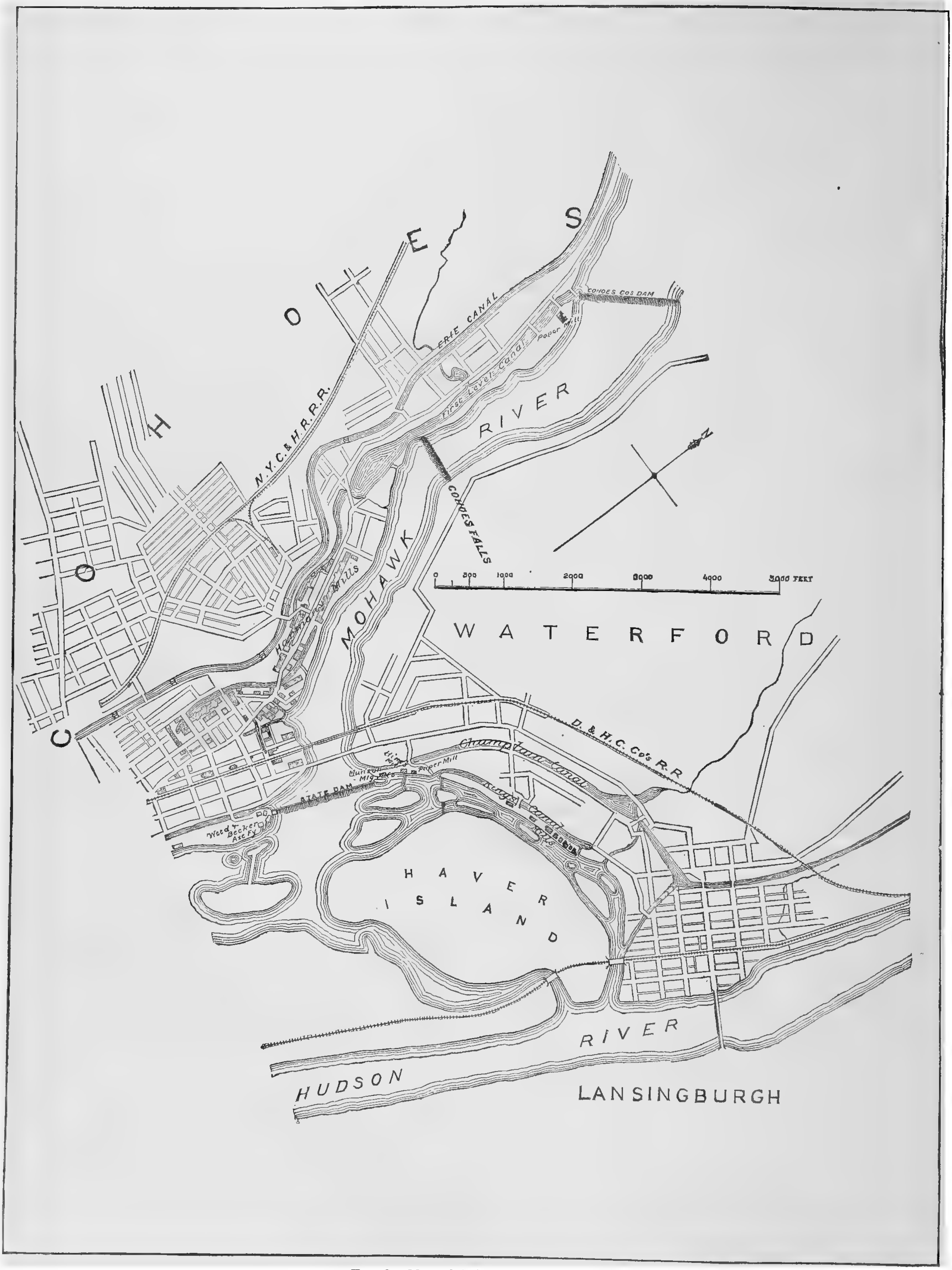

FIG. 6.—Map of Cohoes and Vicinity.

10 feet. It rests throughout upon rock ledge, and is strongly built of limestone masonry, having a width at base of about 13 feet and a front slope of 2 vertical to 1 horizontal. The coping-stones are 10 feet long with the stream, 3 feet wide, 2 feet thick, and the upper surface slopes down stream 1 vertical to 4 horizontal. The masonry of the dam is well bonded by headers and stretchers. The coping-stones are doweled together, and long drift-bolts unite them firmly to the body of the stone-work. At either end of the dam are masonry abutments, and a short distance above the gate-house a pier in connection with the old dam of 1831 serves as an ice-breaker. The cost of the new dam and its connecting work is stated to have been $180,000.

The bulkhead is of cut stone, and is surmounted by a neat brick building containing the machinery of the gates. Of these there are 9 connecting with the canal, presenting rectangular openings 8 feet by 9 feet in size and amounting in the aggregate to 648 square feet. These openings are covered by flat cap-stones, and separated by piers 3 feet thick. A tenth opening admits water to a turbine wheel of 20 or 30 horse-power used in operating the other gates. The gate-house contains also two overflow weirs of 36 feet each, discharging to the river; one opens from above and the other from below the bulkhead. There is another waste-weir, 80 feet long, immediately below the gate-house, opening from the canal to the river, and built of masonry. In addition to the 36 foot overflows there are two 9-foot gate-openings toward the river—one above the bulkhead, connecting the pond and river, and available for drawing down the former; the other below the bulkhead, and available for drawing down the canal.

The machinery for raising and lowering the gates is very easily operated and satisfactory in working. The turbine already spoken of is at the river end of the bulkhead, and operates three lines of shafting; one of these, $2\frac{1}{4}$ inches in diameter, runs in at right angles to the stream and connects with the head-gates; the other two run in either direction parallel to the stream and connect with the waste-gates. Each gate has attached to it two vertical iron posts with racks. Opposite one post of each gate is a pair of beveled friction-wheels revolving in parallel vertical planes; a third wheel, revolving in a plane at right angles to these, can by a small hand-wheel be brought in contact with either accordingly as it is desired to raise or to lower the gates. The turbine is started and sets in motion the long horizontal shaft and the odd friction-wheels; in the manner just described the motion is now communicated to one of the adjacent friction-wheels, which is thus made to revolve, and with it its iron shaft, having a worm-gear; this turns a large vertical toothed wheel, on the axle of which is a smaller toothed wheel directly engaging the rack, which is firmly connected with the gate. On the same axle is another toothed wheel, opposite to, and engaging, the other rack of the same gate.

So far as obtaining the full benefit of the fall at Cohoes is concerned the privilege is very thoroughly developed. Near the dam the Cohoes Straw Board Company draws a small amount of water from the upper level under $8\frac{1}{2}$ feet fall, and discharges into the river; but, so far as was ascertained, that is the only exception to the water being used over and over again from different levels until finally discharged from the lowest canals into the pool above the state dam. Nine separate canals are in use, as follows:

No. 1 runs from the dam about 1 mile in a course approximately parallel to the river. It is 80 feet wide at the water-surface, with an average water-depth of 10 feet. (*a*) With the exception of pumps for the city water-supply, the only use of power on this level is by the Harmony mills. The fall to No. 2 is 18 feet.

No. 2 is about half a mile long, and is used entirely by the Harmony mills. It is 60 feet wide by 8 feet deep, with a fall to No. 3 of 25 feet.

No. 3 is about three-quarters of a mile long, and is used by 20 or 30 mills. It measures 60 by 9 feet, and has a fall of 22.7 feet to the level of canal No. 4. It also discharges with the same fall into canal No. 5, which is carried 1,000 feet in an underground arched way and used merely as a conduit.

Nos. 4, 5, 6, and 7 are all on the same level. No. 4 is about 1,200 feet long and 30 by 6 feet in cross-section. No. 5, already mentioned as running underground, is 25 feet by 8 feet. No. 6 is 1,000 feet long, 20 feet wide, 8 feet deep, with a fall of 14 feet to No. 9. No. 7 is say 800 feet long, 30 feet wide, 8 feet deep, with a fall of 19 feet to No. 8.

No. 8 is about 800 feet long, 20 by 8 feet in cross-section of water-way, and has a fall of 19 feet to the river.

No. 9 is 20 feet wide, 10 feet deep, with a fall to the river of 24 feet.

Cohoes is built upon a foundation of solid rock, through which the canals have to a large extent been excavated; where they do not have natural rock walls, artificial ones of stone or timber have been built. The mills are located in some cases upon the margin of the level from which they draw water, in others beside the level to which they discharge, receiving their supply from the higher canal through trunks or flumes. An interesting contrivance for getting rid of ice in the upper level should be mentioned. Canal No. 1 terminates in a "dead end" at the Harmony mill, and ice accumulates there in winter and is liable to cause serious trouble unless removed. To effect this a shaft was sunk there 40 feet deep in the rock, and connected by a tunnel with the river. This tunnel is 7 feet high at the center, 5 feet wide at the base, and descends by a grade of 1 in 12; it is 375 feet long, and in its course passes successively under canals Nos. 2 and 3. Through two gates, each 5 feet square, a very heavy rush of water can be caused from the canal down the shaft and out through the tunnel to the river, and by this means the canal is successfully and easily cleared of ice such as would be likely to cause trouble.

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a The dimensions vary slightly along all the canals, but at the water-surface and for the water-depths are substantially as given.

The Cohoes Company, which is the proprietor of the water-privilege here described, also owns the land adjoining its canals, and to manufacturers gives perpetual lease of land and power, the property remaining subject to a lien of $200 per annum per mill-power; the land may thus be regarded as given outright, and the rental as applying only to the power. Formerly the standard for measuring water here was 100 square inches, which was to be measured through an aperture in thin plate, 50 inches wide, 2 inches deep, and under a head of 3 feet from the surface of the water to the center of the aperture. In 1859 a series of measurements were carefully made, using an old canal lock, and it was found that the old standard corresponded to about 5.9 cubic feet of water per second. Six cubic feet per second, however, was fixed upon and accepted by the lessees as a new standard, and that amount of water under 20 feet head, or its equivalent, constitutes a "mill-power". In order to determine the amount of water used, both weir and flume measurements, in accordance with Francis' formulæ, are employed. The measurements are not made at regular intervals, but whenever there are changes in the wheels, or oftener if for any reason it seems desirable. The cost of water-power at Cohoes, assuming varying degrees of efficiency for the wheels, is shown in the following table:

Table showing the cost of water-power at Cohoes.

Assumed efficiency of wheel.	Equivalent of 1 mill-power in effective horse-power.	Corresponding cost per effective horse-power.	Assumed efficiency of wheel.	Equivalent of 1 mill-power in effective horse-power.	Corresponding cost per effective horse-power.
Per cent.			*Per cent.*		
60	8.18	$24 45	75	10.22	$19 57
65	8.86	22 57	80	10.91	18 33
70	9.54	20 96	85	11.59	17 26

NOTE.—A mill-power costs $200 per annum, and corresponds to 6 cubic feet per second under 20 feet head, or 13.63 theoretical horse-power. The price stated covers also land necessary for building-purposes.

The permanent power of the privilege not yet being fully employed, the question of surplus powers has not assumed importance.

The growth of Cohoes has been great, and certainly warranted by the admirable advantages which it presents for manufacturing by water-power. As shown above, the rates for permanent power are very favorable, and the substantial character of the hydraulic works, together with the able management under which they are conducted, gives assurance to mill-owners that no ordinary disaster can interfere with their receipt of a full and uniform supply of water. The shipping facilities could scarcely be surpassed. For the greater part of the year there is the best of water communication in three directions: South, about 154 miles to New York, by way of the Hudson river from Troy or Albany; west and north, by the Erie and Champlain canals, respectively, which pass through the city. Railroad communication is afforded by the lines of the New York Central and the Delaware and Hudson railroads, reaching out in the same general directions as the water-routes, and also connecting with New England and the coal-fields of Pennsylvania.

It is said that in 1830 there were not more than 150 inhabitants within the limits of the present city. An attempt had been made at manufacturing as early as 1811 by the Cohoes Manufacturing Company, but the enterprise failed and the property was sold to the Cohoes Company. This company was incorporated March 28, 1826, with a capital stock of $250,000, which was increased in 1833 to $500,000. At first the company itself engaged in manufacturing as well as in supplying power to others, but afterward restricted its duties to the latter undertaking. In 1880 the population of the city had reached 19,416.

The pond above the dam extends from 1 to 1½ mile up stream, with an average width estimated at about 1,200 feet, and is seldom or never drawn down more than 2 feet below the crest of the dam. The Cohoes privilege is commonly rated at 120 feet fall, and a minimum, corresponding to that fall, of 10,000 effective horse-power. The actual fall developed, however, as shown by the descent between the various levels, is between 103 and 104 feet. It is stated by the officers of the water-power company that under all ordinary conditions 2,000 effective horse-power can uniformly be relied upon with 24 feet fall. It is probable, however, that in very exceptional circumstances the power may temporarily fall slightly below the limit mentioned. Mr. David H. Van Auken, hydraulic engineer of the Cohoes Company, gives the lowest discharge of the Mohawk during his long experience with it at this locality as from 800 to 1,000 cubic feet per second continuous flow for the 24 hours. If we assume a fall of 104 feet, a flow of 800 cubic feet per second, and a wheel efficiency of 75 per cent., then the minimum power of the privilege as at present improved will be represented in round numbers by 7,000 effective horse-power. In 1880 a total of 6,556 horse-power of wheels was returned by the census enumerators as in use from the Mohawk at Cohoes. The company still has permanent power to lease on its lower levels, canals Nos. 7 and 8 being yet open a quarter of a mile each for building-purposes.

Estimate of the flow and power at Cohoes.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*104 feet fall.*	
Minimum flow							800+	90.88+	9,450+	
Low water, ordinarily dry year	9½	12	9½	9½	40½	3,490	900	102.24	10,630	*a* 6,556
Low water, average year							1,050	119.28	12,400	
Available 10 months, average year							1,600	181.76	18,900	

a In 1880. Up to the fall of 1882 the power in use was stated to have increased by perhaps 300 horse-power.

First in importance among the Cohoes industries, and the one requiring the principal use of water-power, is that carried on by the Harmony Mills Company, the most extensive manufacturer of print-cloths in the United States. This company gives employment to 3,700 hands, runs 6,200 looms and 280,000 spindles, and produces 125,000 pieces, at 45 yards each, per month. In the largest mill, No. 3, are 2,650 looms and 125,000 spindles. The main building of this mill is 1,170 feet long, with a wing of 210 feet, is 70 feet wide and 5 stories high. The company has a local monopoly in the manufacture of cotton cloth. Next in importance is the manufacture of knit goods, which began its history in this country at Cohoes in the year 1832. The invention of the knitting-frame, by Timothy Bailey, gave a great impulse to the business, which has since wonderfully developed. It is stated that in the fall of 1882 there were 18 knitting-mills at Cohoes, running in the aggregate not far from 130 sets of machinery and giving employment to nearly 2,500 hands. The Cohoes Rolling Mill has extensive works, and other establisments are engaged in the manufacture of machine work, paper boxes, straw-board, bobbins, cotton-batting, sashes, doors, and blinds.

Fig. 7.—Harmony Mill, No. 3.

The Mohawk above Cohoes.—The next important fall is at Crescent, 1½ or 1¾ mile above the Cohoes Company's dam. The Mohawk is there 1,100 or 1,200 feet wide, and near the head of the rapids is crossed by the Erie canal on what is called the "lower" aqueduct. Rocky rifts extend about half a mile along the stream, with a fall stated to be 14 feet. The river runs shallow down these rifts, except for a width of perhaps 150 feet near the head, where there is a low-water depth of 5 feet. The material of the river-bed is a hard slate rock, becoming shaly toward the foot of the shoals. The south bank is rocky and abrupt, while that on the north has a moderate slope and is composed of earth underlaid by rock.

A short distance below the aqueduct a rude leaky wing-dam a couple of feet high runs out obliquely into the stream about 260 feet, and then strikes up stream to the aqueduct. Water is thus diverted into the race, which is 600 feet long and from 15 to 20 feet wide. It extends down the north bank of the river to a point where the available fall ranges from 5 to 8 feet, according to the stage of water. The power is used by L. W. Mansfield for a 3-run grist-mill and a little saw-mill. Only a small portion of the flow of the river is commanded by the rude works, and in a low stage enough water is obtained for only one wheel. Mr. Mansfield owns on the north bank the whole length of the shoals, and claims that a dam 4 feet high at their head would give 16 feet fall at a point say 300 feet below the present mill. Judging from the table of elevations which has previously been given, and from the falls in use at Cohoes and below, the fall at Crescent would appear to be naturally not more than 8 or 10 feet, or, with a dam 4 feet high at the head of the shoals, 12 or 14 feet. Considering the width of the river, the probable expense of improvements, and the absence of any direct railroad facilities, the power to be obtained seems hardly large enough to render the privilege an attractive one.

Estimate of power at the lower aqueduct.(a)

Stage of river.	Flow per second, average for the 24 hours.	Theoretical horse-power.				Effective horse-power utilized.
	Cubic feet.	1 *foot fall.*	12 *feet fall.*	14 *feet fall.*	16 *feet fall.*	
Low water, dry year	900	102.24	1,230	1,430	1,640	Perhaps 25 or 50.
Low water, average year	1,050	119.28	1,430	1,670	1,910	
Available 10 months, average year	1,600	181.76	2,180	2,540	2,910	

a Available fall not definitely ascertained.

The heavy ice-runs which visit the Mohawk are sometimes particularly noticeable in this part of its course. In the spring of 1882 a gorge formed at some point below Schenectady, gave way suddenly, and in three-quarters of an hour the river rose nearly 3½ feet at Crescent, sinking away afterward almost as fast. By this rise the bulkhead and a part of Mansfield's dam were destroyed.

Above the shoals at the lower aqueduct there is 3 miles of smooth water, continuing very nearly to the privilege occupied by the West Troy water-works. The dam at that point runs out from either shore to an island in mid-stream, and has a lift of about 5 feet without flash-boards. It was built about the year 1877, and is a log structure filled in with stone. The apron is most of the way 10 feet wide, but for 60 or 70 feet next the right bank it extends in an irregular shape to an extreme distance of 75 feet down stream from the main portion of the dam, and is covered for 20 feet with squared timber, and the rest of the way with round logs from 6 to 10 inches in diameter, the interstices filled in with loose stone. The dam runs out from the left bank to the head of the island, and the other section reaches on from the foot of the island to the right bank. With 6-inch flash-boards the head obtained is 8 feet. Two wheels are run, one of 40 and one of 60 horse-power, and water is pumped to a distant reservoir for the supply of West Troy and Green Island. In spring, and sometimes in fall, a stoppage of the wheels is forced, even for as much as a week at a time in some seasons, by backwater.

Between the New York Central Railroad crossing at Schenectady and the lower aqueduct there is a fall of about 52 feet in a distance of 14.8 miles. Ascending from the water-works privilege toward Niskayuna the river runs through meadows well cultivated and apparently 1 or 2 miles in width. The current is sluggish and the channel is divided by islands. Not far above Niskayuna the meadows disappear and there is a continuous shoal for a mile, more or less. The banks are much of the way rocky and abrupt. The bed appears to be rock, with some gravel covering it. Above this shoal there is a succession of smooth reaches and riffles on to the upper aqueduct, at Rexford Flats. The fall on all these shoals is quite uniform, and at only a moderate rate.

At Rexford Flats the Erie canal again crosses the Mohawk, on an aqueduct of fourteen arches, and then descends in a short distance through two locks to a 3-mile level, which is fed from the river above. The width of the river at the aqueduct and above ranges from 600 to 700 feet. The surrounding country is hilly, fertile, well cultivated, and has but a moderate amount of timber. The feeder-dam is of stone with a sloping timber apron 10 or 11 feet wide. The fall, without flash-boards, is 6 feet. The abutments are of cut-stone masonry. The feeder is from 25 to 30 feet wide and runs down the left bank, striking the main canal nearly a mile below. No power is in use at this fall.

The banks here appear to be composed of alternate layers of shale and harder slate. The river-bed is covered with loose stone, probably underlaid by ledge. Below the aqueduct the river is perhaps 500 feet wide, and has steep rocky banks rising high and precipitous from the water on the right side, and becoming so on the left a short distance down stream, leaving room there for only the canal. Immediately above the aqueduct a road-bridge crosses the Mohawk. The floor planks of this bridge are 23 feet above low water, but years ago the river is said to have risen almost even with them, and even now freshet-rises of 10 or 15 feet are not uncommon.

From this point on to Little Falls the river preserves substantially the same general features. It has but a moderate slope, and runs usually with smooth surface, broken here and there by short riffles over gravelly shoals. At Tribes Hill the width between banks is somewhat over 500 feet. From the stream there generally stretch out meadows of varying width, beyond which there is a gradual rise to the hills that inclose the valley; occasionally the hill-slopes reach entirely to the river and the meadows disappear.

Four and a half miles below Little Falls the Mohawk is again drawn upon to supply the Erie canal, which it does through a feeder 3¼ miles long. The feeder-dam is of masonry, with ashlar-faced abutments rising 8 or 10 feet above the natural crest. Wide meadows border the stream on both sides. The dam has a lift of 3 feet, increased to 5 feet by flash-boards, and sets back the river as far as Little Falls.

Power at Little Falls.—The hills here close in, the meadows cease for a time, and the stream is confined in a narrow, rocky, and wonderfully picturesque little valley. Entering this pass, the New York Central railroad and a carriage-road skirt the left bank, while on the opposite side are crowded the Erie canal and the new West Shore railroad. Huge ledges appear in the river bed and banks and in the valley sides. Down near the river the

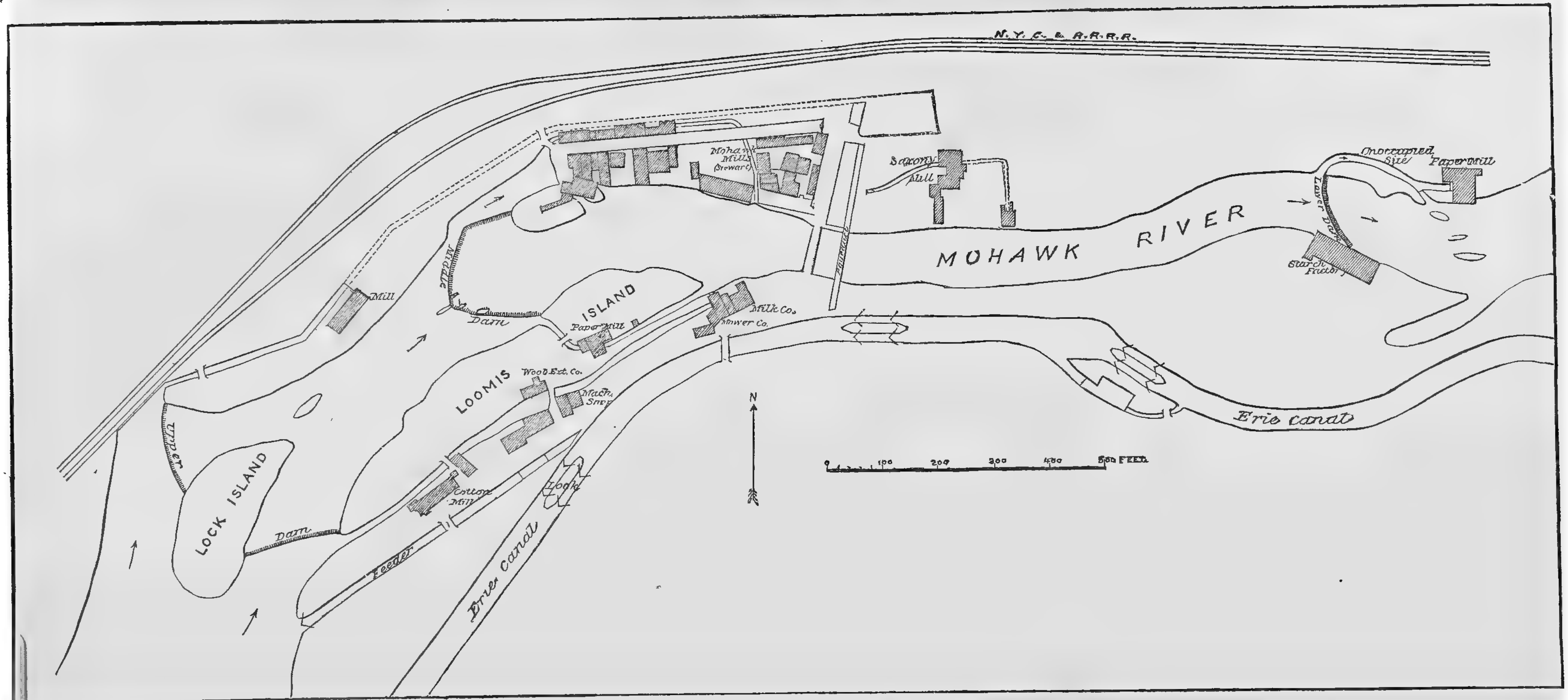

FIG. 8.—Plan of Water-Privileges at Little Falls.

prevailing rock seems to be a pinkish granite. Pot-holes are to be seen in this rock far up on the river-banks, 200 feet distant from the water, and it is said that they exist even on the very tops of the high hills which shut in the valley. The Mohawk has a rapid descent through Little Falls, amounting to about 45 feet from the surface of the pool above the state dam down to slack-water below the lower falls, a distance of from 2,500 to 2,600 feet. In this interval it is dammed and used for power at three different points, an aggregate of about 1,300 horse-power of wheels being employed for manufacturing purposes.

The first or lowest dam in order is a log structure consisting of several sections of varying height, running in an irregular line from the left bank across and down stream to the opposite bank. At the left or north end is a bulkhead of rubble masonry 33 feet long, 7½ feet wide, and 12 feet high above the tops of the gate-openings, which are arched. The admission of water is controlled by seven wooden gates operated by levers. A canal runs from the bulkhead 450 or 500 feet to a mill, and is inclosed in part by a natural ledge and in part by an artificial wall of dry stone. The privilege on this bank includes half the flow of the river and is divided into two equal shares. One of these is owned by Judge A. Loomis, of Little Falls, and is unoccupied. It would furnish a good power most of the year, presents a favorable building-site, and is for sale or rent. The other share is owned by E. B. Waite & Co., who have a mill for the manufacture of manila paper, with a capacity of 2½ tons per day. They obtain 11 feet fall, and estimate that they actually use about 125 horse-power. During the dry autumn of 1882 they were short of water more or less of the time at night.

That half of the privilege on the south side of the river is owned by the J. J. Gilbert estate. The Little Falls Starch Works, also operated under the old firm name of J. J. Gilbert, use 8 feet fall and two wheels—one of 20 and one of 30 horse-power. They employ 14 hands, and manufacture about 3,000 pounds of starch daily. One hundred and twenty horse-power is leased to the Parker Electric Manufacturing Company. Below this fall the river becomes comparatively sluggish, and spring high water sets back so as to stop the mills for a day or two at the privilege just described. A more serious difficulty encountered is from ice. Gorges form in the river a short distance below, throw the water back, and in some seasons cause a stoppage of the mills for two or three weeks. Many years ago they were even forced to shut down all of one winter.

At the site of the second or middle dam the river-bed is a mass of ledge rock worn full of pot-holes. The dam itself is a rough log structure running across in a very irregular line, projecting well up stream, and with a long wing extending down from the bulkhead on the north side, and forming for some distance the river support and overflow for the race. The main canal and the principal use of power are on that side, but a short race leads also down the south bank. The power on this latter side is owned by Judge Loomis and rented or leased to the present user. There are two falls, of 12 and 7 feet, respectively, at which a total of about 80 horse-power is used by William Kingston in a small last-factory, and a larger mill for the manufacture of straw wrapping-paper with a capacity of 1 ton per day.

At the north end of the dam water is admitted to the race through a wooden bulkhead, and is carried 800 or 900 feet down the river-bank, supplying, under falls ranging from 11 to 20 feet: Trask Brothers' ax factory, using 100 horse-power; the Henry Cheney Hammer Company's works, having 2 wheels of an aggregate of 110 horse-power, though the entire amount is not used; the mills of the Saxony Knitting Company and Messrs. Ablett, McKinnon, & Co., the former running 6 and the latter 2 sets of machinery on knit underwear; 3 saw-mills, a 5-run flouring-mill, and one or two other small concerns. Perhaps midway along the race there is a plot belonging to the estate of the late A. T. Stewart, of New York, and occupied by extensive stone mills formerly used in woolen manufacturing, but now vacant. Immediately below is an unoccupied site owned by Victor Adams. Owing to the fact that part of the water from the upper fall is discharged into the river below the middle dam, the privilege just described has a less supply than either the one above or the one below, but for the greater part of the year there is enough for the works now in operation.

The third or upper dam is a low affair, from 2 to 4 feet high, built of logs, rude and leaky; it extends from either shore to an island, and has a slight curve up stream. On the north bank the only use of power is by the Little Falls Knitting Mill Company, running 9 sets of machinery in the manufacture of knit underwear. Water is brought several hundred feet from the dam through what was either the old Erie canal or a feeder to it. The mill obtains 5½ feet fall and has two 25 horse-power wheels. The supply of water is short in summer, and steam is used all the time for auxiliary power. On the south side of the river the pool above the dam is drawn upon not only by an hydraulic race, but also by a feeder to the Erie canal. Water is admitted to this feeder through an opening of 23 feet in the clear, between walls of cut-stone masonry. The draught for canal purposes is tolerably uniform through the boating season, but naturally varies somewhat with the volume of business.

The entrance to the hydraulic race is through an arched bulkhead of heavy masonry. The main portion of this is 75 feet long, 11 feet wide, and rises 7½ feet above the top of the arch. Water enters through 7 gates and passes perhaps 200 feet to the upper mill. This is the Little Falls cotton mill, running 5,750 spindles and 122 looms in the manufacture of prints; 7 feet fall is obtained, and power taken from one wheel of about 75 horse-power. There is at times a slight scarcity of water, though it is thought there would be plenty with a tight dam. After leaving the cotton-mill the water passes down through a race, over two successive falls, and supplies power first to

Reddy's machine-shop and the works of the Little Falls Wool Extract Company, and secondly to the Warrior Mower Company's factory and an establishment for the manufacture of condensed milk; the middle fall is from 6 to 8 feet and the lower from 11 to 12 feet.

The Mohawk above Little Falls.—Above the section already considered the Mohawk is a sluggish stream, having a fall of only 68 feet in the 37½ miles below Rome, (*a*) and flowing through a wide open valley, rich agriculturally, and devoted to the raising of potatoes, wheat, corn, hops, and other products. The first dam above Little Falls is at Rome, where an important draught is made by the state for feeding the 56-mile level of the Erie canal. To accomplish this there is a low curving dam of cut-stone masonry which diverts water through a feeder. The river is in that vicinity about 120 feet wide, with gravelly bed and low banks. A short distance above Rome there is an old log dam forming a pond of a few acres from which water is pumped to a distributing reservoir for the supply of the city; the fall at the dam is made use of to furnish power for pumping, and two wheels, of about 100 horse-power each, are run under a head of 10 or 12 feet. No information was gained of any important power, either improved or unimproved, on the river above this point, and its only use seems to be by a few small flouring- and saw-mills. Some wastage is said to be received from the Black River canal, but the latter serves mainly as a feeder to the Erie, which it joins at Rome. The Erie also receives a considerable amount of water from large reservoirs in the Black River basin, which is diverted to the upper Mohawk, through the Lansing kill, some 23 miles by river above the Rome feeder-dam. From a distance of a few miles above Rome the country on to the head-waters is described as rough and hilly.

Drainage areas of the Mohawk river. (*b*)

	Sq. miles.
At Rome	184
At Utica	524
At Little Falls	1,272
Below the mouth of Schoharie creek	3,122
At the mouth of the Mohawk river	3,493

TRIBUTARIES OF THE MOHAWK RIVER.

Schoharie creek.—This stream rises in the southern part of Greene county at a distance of 10 miles westerly from the Hudson river. It runs northwesterly 16 or 18 miles by general course, and then northerly about 50 miles to the Mohawk, which it joins at Fort Hunter. The drainage basin includes 308 square miles at Gilboa, 684 at Central Bridge, above the Cobleskill, and 947 square miles at the mouth. Within this area are comprised the greater part of Schoharie county, and portions of the counties of Greene, Albany, Delaware, Otsego, Montgomery, and Schenectady. The Delaware and Hudson Canal Company's railroad runs from Albany at right angles to the direction of the stream, and crosses at Central Bridge, but otherwise the immediate valley is not accessible by railroad except at the extreme head-waters. The upper course of Schoharie creek drains the western and northern slopes of a portion of the Catskill mountain range, some of the higher points of which rise to altitudes above tide of 3,000 feet and over. From the head-waters to the central part of Schoharie county the surrounding country is rough and broken, with steep slopes; farther north the hills are more rounded and are arable to the very summits. When this section of country was first settled agriculture was mainly confined to the river-flats, the hills being reserved for woodland; but, it having been discovered that the hills are covered with as fertile a soil as is found in the valleys, they were speedily stripped of the greater part of their timber, which is now confined to limited patches. In the central and southern parts of Schoharie county, and on to the upper waters, the prevailing soil is a clayey and sandy loam containing considerable lime, while farther north there is less sand.

At the Delaware and Hudson Railroad crossing at Central Bridge the water-surface of the creek is 560 (*c*) feet above mean sea-level; immediately below the state dam, near the mouth, the corresponding elevation is 274 (*d*) feet, indicating a fall of 286 feet in the intervening 19 miles, or an average of about 15 feet per mile.

So far as was learned concerning the principal portion of its course, that below Schoharie village, the creek has but little value for water-power, although it can and does sustain some small grist- and saw-mills. It is bordered by alluvial flats subject to overflow, accomplishes its descent chiefly in riffles and shoals without abrupt falls, runs very low in the dry season, and is subject to heavy freshets and ice-runs. Just above the mouth the state draws upon the stream to feed the Erie canal, the estimated supply from this source being about 113 cubic feet per second; (*e*) when visited November 15, 1882, the pool had thus been drawn down 18 inches below the crest of the feeder-dam, and even the small mills within a few miles above complain of a scarcity of water in the dry season. The unusually low volume to which the stream sinks can probably be explained by the cleared and cultivated condition of much of the country drained, the steep slopes in the upper basin, the absence of any

a From the crest of the Rome feeder-dam to the crest of the Little Falls feeder-dam.

b Natural drainage areas, not including the district made artificially tributary from the Black River basin.

c 555 feet + tide-water at Albany (mean-tide = 4.84 feet + mean sea-level).

d From Erie Canal profile.

e See *Annual Report of the State Engineer*, 1880, page 38.

sustaining ponds or reservoirs worth mentioning, and the fact that, in Schoharie county at least, much of the surface is underlaid by cavernous limestone rocks through which there is a loss by percolation. On the occurrence of heavy storms there is a rapid rise followed by a speedy fall, very high water lasting but two or three days in the lower course. At Mill Point, 3 or 4 miles from the mouth, a rise of 4 feet in 6 hours is said to have been observed. The common freshet-rise in that vicinity is not, however, over 6 or 7 feet.

In ascending the stream the first dam encountered is a couple of thousand feet above the mouth, and is owned by the state. It is about 540 feet long and has a lift of 6 feet. There is a flat slope each way from the crest, that on the down-stream side being 26 feet long and serving as an apron. The dam is of heavy timber, but is evidently old, and is considerably battered. For 120 feet next the west bank the apron is prolonged 15 feet still farther from the crest than above mentioned. The abutments are of masonry, and for some distance up stream and down, the river is walled with stone to a height of 8 or 9 feet above the crest of the dam. The stream-bed is here covered with loose rock, bowlders, and gravel, and a little way above, at the West Shore Railroad crossing, an excavation for the easterly pier of the bridge showed the same material to the depth reached, 7 feet. From the pool above the dam, water is admitted through a gate-way 17 feet wide to the feeder canal, which then runs easterly about 3,000 feet in a straight line to the main trunk of the Erie canal. The latter crosses Schoharie creek a few hundred feet below the feeder-dam on a stone aqueduct of 14 arches.

No water-power is employed at the feeder-dam, and the first use of the stream for that purpose is at Auriesville, perhaps a mile or more above. The mill is isolated, the surrounding district being rather sparsely settled by a farming class. The stream is here flanked by broad meadows of the greatest fertility. These are covered with a black alluvial soil, preserving the same character to a depth of 5 or 6 feet. For forty years these flats have been cultivated in broom-corn, oats, Indian corn, and barley without once being artificially enriched, yet they continue to yield splendid crops. On the uplands grass and all kinds of grain are raised. A considerable amount of timber is still standing in the adjacent country, embracing pine, oak, hemlock, with some maple and hickory.

At Auriesville the immediate valley is in the neighborhood of half a mile wide and is succeeded by a rise to rather low hills. The stream-bed is covered with loose rocks forming rifts; the fall on these is said to be slight, but they occur at intervals all the way from the state dam as far at least as Mill Point. For the mill-privilege a low line of rocks across the stream makes a shallow pool, from which, through a rude bulkhead with paddle-gates worked by iron rods and levers, water enters a small race and runs perhaps a quarter of a mile across the flats to the mill which is at the foot of the bordering hills. The mill is owned by Peter Veeder, has 3 saws and 3 runs of stone, power being taken from a 5-foot Lessner turbine, on which the head is 7 feet in a favorable stage of the stream. The water is returned to the creek through a tail-race of about the same length as the head-race. For two months in the year the supply of water obtained is insufficient for running the mill. On the other hand, freshet backwater also hinders. The stream usually floods the meadows during the spring rise to a depth of a foot or two, now and then entering the mill. In October, 1869, it rose high in the mill, and must have run 7 or 8 feet deep over the meadows. Ice generally collects below at the state dam, and a few years ago a gorge formed there which stopped Veeder's mill by backwater for ten days. Ice also runs out on to the flats and leaves considerable deposits of gravel.

At Mill Point, 3 or 4 miles above the mouth of the creek, James J. Faulkner has a 4-run grist-mill, a small saw-mill, and a broom-handle factory, at which not less than 200,000 feet of lumber is stated to be annually worked up. Seven water-wheels are run, old-style iron turbines, estimated at about 140 horse-power total capacity. The entire fall on the privilege is 17 feet, but of this 3 feet is taken up in the races. The stream makes a long bend here, across the base of which water is conveyed to the mills in a head-race say 60 rods, and discharged through a tail-race 8 rods in length, while the intervening distance by river is estimated at about a mile. At the site of the dam the bed is covered with gravel and bowlders; a steep clay bluff rises on one side, and on the other there is a more gradual ascent to a flat. The dam runs diagonally up stream, and in a very low stage of water serves to divert most of the flow into the race. It is a timber structure part of the way across, filled in with stone and planked, and has stood for about twenty years. On one bank, the left, it abuts against a wall of dry bowlders, but toward the other bank the timber portion ceases and is succeeded by a low line of stones loosely piled up. The pondage is insignificant. In ordinary years the supply of water obtained answers the demands of the mills, but it is so held back in mill-ponds above as to come down irregularly, and in a very low stage it is thought that the entire volume of the stream would not run all the wheels. A rough estimate of the available power shows the following result:

Estimate of power at Mill Point.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	14 *feet fall.*	17 *feet fall.*	
Low water, dry year	10	13	9½	8½	40	942	70	7.95	110	140	150±
Low water, average year							100	11.36	160	190	
Available 10 months, average year							200	22.72	320	390	

At this locality the creek-bed is variously composed of clay, loose rock, and ledge rock. The common freshet-rise is not more than 6 or 7 feet, and is said not to overflow the flats except when ice-gorges form. As far as Esperance, 10 miles above, the stream is described as uniformly rapid, though without heavy falls, and above that point as flat. In the distance named it is bordered by bluffs, opposite to which are bottoms of from 50 to 100 acres, and its course is very winding; then there are bottoms on both sides up to Schoharie. In the vicinity of Mill Point the bluffs are of blue clay, but at other points slate rock. Schoharie village is the most important point directly on the stream, and has a population of 1,200. The creek has there an average width of about 250 feet, alluvial banks, and a somewhat gravelly bed; in summer it runs shallow and with scarcely any current, but after a long-continued rain it becomes swollen to a fierce torrent and overflows far and wide the adjacent low lands.

East Canada creek.—This creek has its source among the mountains in the southwest part of Hamilton county within a few miles of Piseco lake. It flows southerly and joins the Mohawk 6½ miles below Little Falls, in its course passing across a corner of Fulton county, and then forming the boundary between that county and a part of Montgomery on the east and Herkimer on the west. The drainage basin contains an area of 299 square miles, and the stream has a length of about 26 miles by general course. When visited in the middle of November, 1882, after a season of unusual drought, East Canada creek was carrying an important volume of water. It must be a valuable feeder of the Mohawk, and would make a fine water-power stream, the principal trouble being that at numerous points where there is a large fall the ground is not well suited to building on account of the steep banks and narrow valley. The land immediately adjoining the lower course is timbered with small hemlock and other trees, but the surrounding country has been pretty thoroughly cleared. The latter is quite broken for the first 3 or 4 miles north of the Mohawk, but then becomes more regular though still rolling. The fall in the creek is rapid, and from Dolgeville, 6½ miles above the mouth, to Little Falls, the descent is said to have been shown by a railroad survey to be about 500 feet.

The stream is not employed for logging, although timber is cut near the head-waters and floated down the Sacondaga. Spruce is the main variety now left; the hemlock has been chiefly cut away, but there is still abundance of hard wood. The water of the creek is largely derived from springs, is soft and very pure, never leaving any film or sediment in boilers. Numerous lakes are drained, of which the East Canada group, several in number, was mentioned as presenting good opportunities for storage. This group is distant 15 or 20 miles by road from Dolgeville. It is claimed that by raising the outlet to the lower lake the surfaces of all, which are connected upon nearly or quite the same level, could be raised several feet. The outlet of Feris' lake joins the main creek a short distance above Dolgeville, and it was stated that this lake could also be used as a reservoir, and if desirable raised 20 feet, overflowing only poor land. The lake is described as a mile or more long and of good width. The flow of the creek is tolerably well sustained in the dry season, but is becoming less so every year on account of the cutting away of timber. The fall is so rapid that freshets do not attain great height and soon run out. There is a run of ice in spring, but no damage is reported as resulting from that cause.

At the mouth the creek is about 200 feet wide between banks, but in a low stage the actual width of water-way is less. The lower course for say 3 miles from the Mohawk is through a narrow, rocky, and wooded valley, and contains a number of abrupt falls. One mile above the mouth the creek is said to descend 180 feet in three-quarters of a mile.(*a*) Between the mouth and Ingham's Mills was noticed a paper-mill recently built and not yet in operation. It is located at what are known as the "Beardsley" falls, where the stream pitches down over a series of ledges formed like a flight of steps. A wooden flume carries water to the mill and gives a head, measured to the surface of the pool below the falls, of about 25 feet. There are other falls unoccupied just below.

Three miles or thereabout from the mouth the valley becomes more open, the hills receding, and there are some farms; the banks are of moderate height, the bed consists of gravel or low ledges, and the fall is rapid but not so abrupt as below. This section could undoubtedly be used to good advantage for power.

At Ingham's Mills, between 3½ and 4 miles from the mouth, there are a 2-run grist-mill, a small saw-mill, a cider-mill, and a cheese-box factory. The water-privilege is improved by means of a log dam said to be a hundred years old, and a race some 60 rods long, and has about 10 feet fall. The mills can run at full capacity nine months in the year.

A quarter of a mile below Dolgeville there is a fine fall of 50 or 60 feet in a short distance, the theoretical power of which, assuming the entire fall as available, may be estimated as below:

Estimate of power at the falls one-quarter of a mile below Dolgeville.

Stage of river.	RAINFALL ON BASIN. [Roughly approximate; no data for accurate determination.]					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*50 feet fall.*	*60 feet fall.*
Low water, dry year	9	13	10	8	40	269	70	7.95	400	480
Low water, average year							90	10.22	510	610
Available 10 months, average year							130	14.77	740	890

a See page 346, *Historical and Statistical Gazetteer of New York*, 1860.

At Dolgeville is the most important use of power on East Canada creek. From moderate beginnings the works have grown until they have now become quite extensive, giving employment to about 300 hands and carried on in two fine mills. The property is owned by Mr. Alfred Dolge, who manufactures felt, piano and organ sounding-boards, and has also a grist-mill. The felt-mill is a fine structure of stone, 260 feet long by 75 wide, while the sounding-boards are made in a wooden factory 200 by 40 feet in size. There are two log dams here, but only the upper one is used. A flume from 350 to 400 feet long carries water to the mills, where the extreme fall obtained is 20 feet. The estimated capacity of the wheels is a total of 290 horse-power. In the stone mill there is a 120 horse-power iron turbine, but the other wheels are wooden and of old patterns. The stone mill is also to have an engine of the same capacity as the wheel. The stream can be depended upon here for the entire amount of power needed in ordinary years, except during say July and August, and Mr. Dolge estimates that with 20 feet fall 100 effective horse-power can always be realized. Dolgeville is 6½ miles from the mouth of the creek, and is without railroad connections. A line has been surveyed, however, to run from Little Falls through Dolgeville, Devereaux, and on to Piseco lake.

West Canada creek.—Rising near the center of Hamilton county, between 45 and 50 miles north of the Mohawk, and 13 miles to the north of Piseco lake, this stream flows in a southwesterly direction from 38 to 40 miles by general course, and then on the eastern edge of the town of Trenton, Oneida county, turns and runs southeasterly and then southerly through a farther distance of 20 miles, emptying at the village of Herkimer. The source is in an elevated region whence also flow the Cedar and Indian rivers to the upper Hudson, and the Black river to lake Ontario. Its water-shed includes an area of 548 square miles, within which are many lakes, Transparent lake, the largest, being represented on French's map as about 4 miles long and a third of a mile wide. For about 15 miles from the mouth to Poland the Herkimer, Newport, and Poland railroad follows the immediate valley. The stream is also approached at Trenton by the Utica and Black River railroad, but the greater part of its course is not directly accessible by rail. The largest villages on the stream are Herkimer, at the mouth, 2,400 inhabitants, and Newport, 11 miles above, with 700.

There are no data at hand from which to give frequent elevations along the course of the stream. According to Colvin's *Survey of the Adirondack Region*, Transparent lake, which is not, however, the most distant source of the stream, is 2,187 feet above the sea. The track of the New York Central railroad at its crossing near the mouth is 403 feet above the same datum-plane, indicating an intervening fall in the water-surface of approximately 1,800 feet. So far as could be judged from a hasty examination, that portion of the stream below Prospect, in which the drainage area increases from 358 square miles to 548 at the mouth, is inferior to the lower portion of East Canada creek in value for power, except perhaps as regards the volume of flow. Below Trenton Falls the valley of West Canada creek is more open than the lower valley of the other stream, but the fall is described as being only moderate in amount. From Prospect down to the foot of the Trenton falls the descent is very great, but it takes place in a narrow chasm varying from 50 or 60 to much beyond 100 feet in depth, and frequently so contracted and rugged that improvement of the fall by ordinary methods would be impracticable. There are no artificial reservoirs, and the dry-season flow appears rather less well sustained than that of East Canada creek. Heavy runs of ice occur, and there are violent spring freshets, during which the flats near the mouth are submerged.

The first power in use, ascending the stream, is encountered at Herkimer, and is improved by a timber dam resting on gravel and rock. Several years ago one-quarter of the dam became undermined by overflowing water and was carried away. Water passes to the mills through a race 2 miles long, broadening out in one part to a lake half a mile long and a quarter of a mile wide. In the lower part this race is from 30 to 35 feet wide and 5 feet deep. The tail-race from the lower mills is at least half a mile in length. The water is used in two falls of 21 and about 14 feet, respectively. The upper fall, of 21 feet, is occupied by the Herkimer Paper Company, manufacturer of news and colored papers, producing 5 tons per day. About 150 horse-power is in use. The lower fall is nominally divided into square feet under 14 feet head, but the head actually obtained is said to range ordinarily from 13 down as low as to 10 feet. Power is used by a saw-mill, 2 sash-, door-, and blind-shops, a 4-run grist-mill, a plaster-mill, a knit-goods mill, and a furniture factory. There is in some years more or less scarcity of water for one or two months in summer; slight trouble is also experienced from backwater, and in some winters the mills are shut down several days by anchor-ice.

From Herkimer to Trenton Falls, some 20 miles above, the stream is described as in general wide, and running over a gravelly bed with rifts but no heavy falls. In this interval there are said to be no powers of consequence in use, except at Middleville and Newport, at the former of which places there are a grist-mill and a tannery.

At Trenton Falls the stream passes through a wonderful gorge in the hills, pitches abruptly down in a series of falls, and gives rise to the charming scenery for which the locality is famous. A considerable portion of the fall might doubtless be turned to avail for power, but the present owner of the property adjoining the principal falls is not in favor of any such encroachment upon the natural beauties of the place, and it would indeed seem like a desecration to supplant the charms of this favored spot by the homely surroundings of an ordinary manufacturing village.

The lowest available privilege is at the foot of the series of falls, and is occupied by William A. Morgan for a 3-run grist-mill. It is improved by a timber dam 212 feet long and 9 feet high, built in 1869 or 1870. A sudden

fall of 5 feet immediately below increases the head at the mill to 14 feet. There is always a wastage on the dam, and when visited, in a very low stage of the stream, there was 6 inches of water on the crest, the mill not running at the time. Five feet is the extreme freshet-rise seen on the dam during a number of years. Two years before it was rebuilt the original log dam was carried out at each end. The poundage obtained here is very small. Ice is thoroughly broken up in coming down through the gorge above, and goes over clear of the dam; some roots of trees are brought down at times, however, and threaten the structure. Freight rates are complained of as high at this point, and are said to be as much to Utica by railroad as by team. In the fall of 1882 they were stated to be 12½ cents per 100 pounds for ordinary freight between here and Utica, a distance of 16 miles, and for car-loads of grain, coal, and similar articles, 7 cents per 100 pounds.

The descent at Trenton Falls is commonly spoken of as 200 feet in half a mile, but exact figures as to its true amount could not be secured. Mr. Moore, owner of the land adjacent to the falls on each side of the stream, gives the fall at four of the principal pitches, in order ascending the stream, as follows: Sherman fall, 24 feet; High fall, 105 feet; Mill-dam fall, 14 feet; Suydam fall, 12 feet.

The sides of the chasm through which the stream runs here are steep, almost vertical, walls of Trenton limestone. Opposite the Mill-dam fall the banks are lower than elsewhere, and by sinking a wheel-pit and tunneling for the tail-race from the bottom, this fall could be combined with the High fall and a very large head obtained. At the top of the banks the ground is sufficiently level for the location of mills.

Estimate of power at Trenton Falls. (*a*)

Stage of river.	RAINFALL ON BASIN. (*b*)					Drainage area.	Flow per second, average for the 24 hours.	THEORETICAL HORSE-POWER.						
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	12 feet, Suydam fall.	14 feet, Mill-dam fall.	24 feet, Sherman fall.	105 feet, High fall.	155 feet, total of four falls.	200 feet, assumed total at Trenton Falls.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*							
Low water, dry year							80	9.09	110	130	220	950	1,410	1,820
Low water, average year	9	13	10	8	40	360	100	11.36	140	160	270	1,190	1,760	2,270
Available 10 months, average year							150	17.04	200	240	410	1,790	2,640	3,410

a Probably not all available in any case, and the total fall uncertain, though commonly stated at 200 feet.

b Roughly approximate; no data for accurate determination. Observations for ten years at South Trenton give an annual rainfall of 54 inches, nearly 18 inches in excess of the amount as shown at Fairfield academy, 14 miles to the southeast and 350 feet higher than South Trenton, by records for 17 years.

The gorge continues from the lower mill-privilege, already described, about 2½ miles up to the Prospect privilege. Immediately above the property owned by Mr. Moore the land for half a mile up stream is owned by Mr. William Perkins. In this distance the cut made by the stream is about 60 feet deep, with steep sides, increasing in height as the lower limit of the property is approached; for a mile above this section the depth is said to average from 60 to 80 feet. The banks either rise directly to level land or consist of two or three shelves where quarried out. The stone is claimed to answer finely for building-purposes; it also takes a handsome finish and is suited to monumental work. It is largely quarried for these purposes and for making lime, and is obtained in blocks varying in thickness from 2 feet downward. There are twelve or fourteen thick layers, and thinner ones beneath. About 30 feet of fall has recently been sold by Mr. Perkins, and will be used for power on the right bank.

At Prospect, 3 miles by direct road from Trenton, there is a splendid privilege having a natural fall of about 22 feet, which could be purchased at a reasonable price. The stream descends in a beautiful sheet over a smooth, massive barrier of rock, at the summit of which a low timber dam extends about a third of the way across from the right bank. Its greatest height is not over 2½ feet, and it runs out on the rock. The banks are level and perfectly adapted to building. The half of the privilege on the left bank is owned by the firm of Hinckley & Blue, having extensive mills farther up stream, and is unoccupied. That on the opposite side is occupied by Henry Hogedorn for a grist-mill, and by Lewis G. Griffith for a tannery. Water is received through a race cut in the solid rock, not over 75 or 100 feet long, and is used under an effective head of 18 feet. The grist-mill has 3 runs of stone and 3 wheels, each of 30 horse-power, and the tannery has one 26 horse-power wheel. There is always a wastage of surplus water on the dam.

Estimate of power available at Prospect.

Stage of river.	RAINFALL ON BASIN. (*a*)					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	22 *feet fall.*	
Low water, dry year							80	9.09	160	200	
Low water, average year	9	13	10	8	40	358	100	11.36	200	250	116 horse-power of wheels; probably not over 70 horse-power actually used.
Available 10 months, average year							150	17.04	310	370	

a Roughly approximate; no data for accurate determination.

Two miles above Prospect, Messrs. Hinckley & Blue have what are known as the "gang mills". They are large mills having two gang-saws of 20 saws each and other machinery. Some 20 miles above are Hinckley's upper mills. Measured by direct course the stream has its source about 38 miles above Prospect. The valley is described as comparatively open for several miles up, after which the mountains are encountered and the slopes become in places very precipitous. For 26 miles above Prospect the adjoining country along the creek is cleared and settled, but from there up is thickly wooded.

Sauquoit and Oriskany creeks.—Sauquoit creek rises in the town of Paris, in the southeastern part of Oneida county, and runs northerly to the Mohawk, emptying a couple of miles above Utica. It is 30 miles long by general course, and drains 62 square miles. Near the mouth, at the Whitesboro' bridge, it is in summer about 80 feet wide, shallow, with a brisk current, and has low banks. It is without artificial storage reservoirs, and is very "flashy" and fluctuating in flow. The first use of power met in ascending the stream is at the extensive New York cotton-mills, about 2 miles from the mouth. There are three mills, or groups of mills, located at two distinct privileges. At the lower privilege, Mill No. 1 has a breast-wheel, 20 feet fall, and say 150 horse-power; Mill No. 2 has a breast-wheel, 30 feet fall, and 350 horse-power. At the upper privilege Mill No. 3 has 30 feet fall and from 300 to 350 horse-power. It is stated that the three mills can run at full capacity by water-power for three or four months in the year, but for the remainder of the time get only about one-third capacity from that source, and are obliged to rely upon steam. Manufacturing is carried on at half a dozen or more localities above on the creek, the principal productions being cotton, woolen, knit and silk goods, forks, and scythes. There were also, in 1880, several unoccupied privileges, of which there were mentioned in particular the old Brownell privilege, at the village of Sauquoit, factory burned; the Farmer's factory privilege, factory burned; and a privilege between Chadwick and Clayville.

Oriskany creek has its source in the town of Madison and county of the same name, whence it flows northerly till it reaches the Mohawk, 6 miles northwesterly from Utica. Its drainage area is 135 square miles. At the village of Oriskany, a short distance above the mouth, the state has a dam a few feet high and from 200 to 250 feet long, for diverting water to the supply of the Erie canal. While canal navigation lasts, usually from May to December, most of the water flowing down is thus used, and the mills just below have either to shut down or to run by steam. These mills have a private dam across the stream a short distance below the state dam, and receive their water through a long canal. The Oriskany grist-mill gets 80 horse-power with 10 or 11 feet fall. The Waterbury factory has 14 feet fall, and obtains 100 horse-power, except during the period of navigation, when steam is largely relied upon. Above the pool of the state dam there is another dam with 9 feet of fall not in use; the privilege was formerly utilized, and there yet stand the ruins of a brick factory which burned. Farther up stream are powers employed by grist-mills, one or two cotton factories, and the Kirkland Iron Works. The bed and banks of the stream are said to be generally of gravel. The flow is comparatively steady, there is no trouble from ice, and near the mouth the ordinary freshet-rise is reported as not over 4 feet.

THE HOOSAC(*a*) RIVER.

This stream, one of the largest tributaries of the Hudson, and, excepting perhaps the Mohawk, the most important in point of manufacturing, takes its source among the mountains in northern Berkshire county, Massachusetts. It first runs northwesterly, passing across the extreme southwestern corner of Vermont and into Rensselaer county, New York. Reaching the northern boundary of that county it turns and pursues an indirect westerly course, joining the Hudson opposite Stillwater. Its basin has an area of 710 square miles, and the river itself has a length by general course, below the junction of the North and South branches at North Adams, of about 40 miles. The principal affluents received are the Little Hoosac river, Walloomsac river, and Tomhannock creek. As well in New York state as at the head-waters in Massachusetts, the country drained is to a great extent rugged and mountainous, the summits of the Taghkanick and Petersburg ranges attaining elevations of from 1,000 to 2,000 feet above tide.(*b*) These mountains are described as having rocky precipitous slopes, and as being partially covered at the top with timber, though displaying many bare masses of rock. The Taghkanick range is mainly composed of slate, quartz, sandstone, and limestone; while the Petersburg mountains are made up of graywacke slates and limestone. The soil on the mountains is poor, but of fair quality on the less elevated lands and in the valleys, and in the vicinity of Schaghticoke are fine corn-lands. Wheat, oats, potatoes, and flax are also raised in different sections, and grazing and dairying are extensively conducted.

The immediate valley of the lower Hoosac lies in a moderately hilly, open country, which is good farming land even to the tops of the hills and is well cultivated. In the vicinity of Hoosac Falls the surrounding country grows more hilly, and at Pownal, and above to the source, the valley is inclosed by high, steep, and rocky slopes, well covered with a young growth of timber. From Hoosac Falls up to North Adams, directly adjacent to the stream are fertile meadows, and the banks are rather low. Above Pownal these meadows do not often appear to exceed half a mile in width between the hills, and they were judged to be generally narrower than that. They render necessary low dams, long races, and in some cases low dikes to prevent overflow; even then the meadows are at times submerged.

a Also often written *Hoosick*.

b Historical and Statistical Gazetteer of New York.

The Hoosac has a large fall, but elevations which should show the true amount could not be obtained, except for one or two very limited sections. A large share of the fall has already been improved, and splendid mills and factories are scattered all along the river's course. On the upper waters, in Massachusetts, the main branches of manufacturing are in prints, cotton-warps, ginghams, and woolen goods. The productions by water-power along the river also include some other varieties of cotton goods than those above mentioned, as well as twines, knit goods, paper, mowing- and reaping-machines, axes, powder, and flour; some of the works, notably those at Hoosac Falls, being of unusually large size. Notwithstanding the number of mills already erected, there is some available fall still undeveloped between Williamstown and Hoosac Falls, while at Schaghticoke, but a few miles from the mouth, far the greatest concentrated power on the entire river remains only slightly improved. The Troy and Boston, and the Boston, Hoosac Tunnel, and Western railroads both follow the course of the river closely from Schaghticoke village to North Adams, and are intersected at several points by north-and-south lines.

During the summer of 1880, which was a year of very small rainfall in this section, the flow of the Hoosac at Schaghticoke was carefully observed under the direction of Mr. Leonard M. Wright, civil engineer, of Troy, who has kindly furnished the results of his examinations. In the latter part of May he computed the flow by taking a cross-section and the velocity of the current, and thus found the volume to be 455 cubic feet per second at what was termed the "ordinary stage" of river. The result was closely verified by a weir measurement on the Schaghticoke Powder Company's upper dam. From May 29 to July 31 the depth on the crest of this dam at 6 a. m., 12 m., and 6 p. m. was recorded daily. The approximate discharge as thus indicated, for the entire period of nine weeks, appears to have been an average of between 350 and 400 cubic feet per second, and the minumum for any one day (average of the 24 hours) about 185 cubic feet per second. This result is at variance with the minimum flow differently estimated by Mr. Wright by computing the amount of water used in the water-wheels at this dam, and by which method he makes the minimum flow about 300 cubic feet per second. The drainage area above Schaghticoke being 625 square miles, a discharge of 185 cubic feet corresponds to about 0.30 cubic foot per second per square mile. The river is subject to heavy ice runs, and is considered to rise and fall quickly after storms. There is but a moderate amount of storage in reservoirs, and that is at the extreme head-waters. The pondage by the dams along the stream is not usually large, and the steep impervious slopes which characterize much of the drainage basin favor the rapid carrying off of storm-waters, from which causes it would be reasonable to expect considerable fluctuations between low and high water.

In ascending the river, water-privileges are met as follows:

Power at Schaghticoke.—The village of Schaghticoke, sometimes called Hart's Falls, has a population of 1,300, is the site of several important manufacturing concerns, and by the large unimproved water-power which it possesses offers facilities for a much farther increase in such industries. It has good railroad connections in all directions, is distant about a dozen miles from Troy, and half that number from Mechanicsville, on the Hudson, where, as we have seen, a fine power has recently been developed for the manufacture of paper and pulp. At this locality the banks of the Hoosac are high and rocky, and the bed is composed of slate ledges dipping to the eastward at a large angle. The width varies, but at the road bridge is about 350 feet between banks. Beginning at the Cable Flax Mills' upper privilege five distinct falls may be recognized directly in the village, three of them more or less used for power at present, and two entirely unoccupied. The total descent on the five falls is about 97½ feet. The mills are all on the right bank, on which side the village is mainly situated, and toward which the natural tendency of the current carries the major portion of the flow.

The upper privilege is improved by a timber dam extending clear across the river, and embraces a fall of 8 feet. Power is used by Wiley & Button, manufacturers of straw wrapping-paper, and by the Cable Flax Mills Company in its No. 3 mill. This company manufactures twines, yarns, shoe-threads, and similar goods, and uses here a single wheel of 60 horse-power. The paper-mill wheels are of old style and their power was not accurately known. At the time Mr. Wright, acting for the owner of the large water-power at Schaghticoke, measured the flow of the stream he also prepared a statement showing the gross or theoretical horse-power that had been sold from each fall. From this it appears that, in the summer of 1880, 121 gross horse-power had been disposed of to manufacturers at the upper fall. Wiley & Button say that there is sometimes a lack of water for their wheels. Two or three winters ago the stream froze very thick and they were short of power for two months.

The second fall is 7½ feet, and is partially improved by a log dam running from the right bank about half-way across to an island. The power here is used by the Cable Flax Mills Company, which has 250 horse-power of wheels, but is short of water for running at full capacity about four months in the year. The privileges here described succeed one another closely, the descent of the stream being very rapid.

The third to be noticed has a total fall of 24½ feet, included in which is a sudden pitch of 12 or 15 feet over a slate ledge. Just above this pitch are the partial remains of an old dam by which the privilege was formerly improved. There were mills at each end of the dam, but they were burned and only a few ruins are left. The site is a fine one, but is reported to have been held at a very high price, which has prevented its development.

The fourth power is the last one in order that is in use on the stream, and includes a fall of 34½ feet. It is occupied on the right bank by the Schaghticoke Woolen Mill, manufacturing fancy cassimeres and worsteds and having 12 sets of machinery. The head actually used here is 30 feet, under which is run one wheel of 170 horse-power.

There is always enough water, and for ten months in the year a waste day and night over the dam. The latter is a log structure, extending from the right or north bank diagonally up stream, and decreasing in height from about 9 feet till, as the river-bed rises sufficiently, it runs out on the rocks at the foot of an island. The entire river is not controlled; but, the island stretching up stream and the main channel setting toward the dam, the larger share of the water is diverted to the mill, which is located directly opposite the dam. The main building is of brick, 180 by 84 feet in plan, 4 stories high, with a large wing of 160 by 50 feet. Employment is given to 220 hands. Immediately below the woolen-mill is a 3-run grist-mill, receiving water from above the same dam through a distinct flume, and using the full fall of 34 feet.

The fifth and last of this series of falls includes 23 feet and is entirely undeveloped. It extends from the woolen mill privilege in heavy rapids down to what is known as the "big eddy", at no great distance below.

The power available at these falls may be estimated as follows:

Estimate of power at Schaghticoke village.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.						
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	Upper fall, 8 feet.	Second fall, 7½ feet.	Third fall, 24½ feet.	Fourth fall, 34½ feet.	Fifth fall. 23 feet.	Total fall, 97½ feet.
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Sq. miles.*	*Cubic feet.*							
Low water, dry year							200	22.72	180	170	560	780	520	2,210
Low water, average year	9	12	9½	7½	38	625	250	28.40	230	210	700	980	650	2,770
Available 10 months, average year							360	40.90	330	310	1,000	1,410	940	3,990

NOTE.—The effective horse-power utilized can not be stated here with accuracy, but in the fall of 1882 there appeared to be in use an aggregate of about 600 horse-power of wheels.

Passing below the "big eddy" the river enters a narrow gorge, and for half or three-quarters of a mile runs with rapid descent between high and abrupt rocky banks. The bed is also rocky. For much of this distance the banks are too steep for the convenient location of mills, but the stream makes some very sinuous curves, and where it approaches the Boston, Hoosac Tunnel, and Western railroad there is an extensive open site having a gentle slope. A little way above this point an attempt was made years ago to utilize power for milling. A brush dam was built, and a race run diagonally across a bend behind a rocky bluff. The dam was carried away, but the canal remains, and an opportunity is presented for developing a good power, though the location has the disadvantage of being much below the grade of the railroad and away from the village, there being no settlement in the immediate vicinity. At the entrance to the old race the river-bed is of rock; the banks are of the same character and high on each side. The race itself is about 25 feet wide, excavated through rock part of the way, and is rather shallow, the bank on one side frequently being but 2 or 3 feet high; it is perhaps 600 or 800 feet long. From the bed of the race, between the old bulkhead walls at its terminus, down to the low-water surface of the river, 100 feet or so distant, the fall is 21 feet, which would be increased 2 or 3 feet from the water-surface in the race. The power corresponding to this fall may be judged by comparison with the estimate above, the volume of the river being practically the same as at Schaghticoke. Below the gorge the river finally issues among wide meadows, and thence to the mouth has but little fall.

As nearly as could be ascertained, the privileges here described were owned substantially as follows in November, 1882: Passing up through the gorge below the village, the estate of George M. Tibbits, (*a*) of Troy, includes all the land on the left bank (left descending) for 1 mile, more or less, nearly up to the woolen-mill fall. On the opposite bank John Downs, of Schaghticoke, owns up to the point where Betsy A. Hart's interest (*b*) begins. Above these proprietors Betsy A. Hart owns continuously on both banks up to the head of the falls, excepting certain limited powers disposed of to the different manufacturers.

The river above Schaghticoke.—A short distance up from the village the Schaghticoke Powder Company has quite extensive works on the south bank of the stream, and owns a total of 20 feet fall in two privileges. The dams are both timber structures, and rest on the solid rock which still constitutes the river-bed. The lower dam is 176 feet long, and varies in height from 18 inches to 10 feet, according to the profile of the rock on which it is built. A glazing-house and two packing-houses are supplied from this privilege, about 50 horse-power being in use. Water is carried from the dam a total distance of 790 feet, in a trunk which decreases from 4½ to 3 feet in diameter, giving a head ranging from 6½ to 12 feet.

The upper dam has a roll-way 214 feet long, with a quite uniform height of about 6½ feet. The wheels on this privilege run under 8 feet head and furnish in the aggregate 158 horse-power. Water is conveyed from the dam 950 feet, part of the way in an open flume 6 feet square, and the remaining distance in an underground trunk ranging in diameter from 4 to 3 feet. Power is furnished to two wheel-mills, a pulverizing-mill, a press-mill, and a corning-mill.

a Represented in Troy by Benjamin Hall, esq.

b Represented in Troy by William H. Doughty, esq.

The powder-mill dam sets the river back from half a mile to a mile, succeeding which is the power at Valley Falls. The dam at that point is built of squared timbers, the face having a small batter. It is 12 or 13 feet high, with top rafters 24 feet long, and is pinned to the bed-rock; it was built in 1881 to replace an old structure, and cost about $4,500. The head obtained at the mills is 15 or 16 feet. On the north side the power is owned and utilized by the Valley Falls Paper Manufacturing Company, manufacturer of straw wrapping-paper. On the south side power is used by the Valley Falls Knitting Mills, Harrington & Crapo's 5-run custom and merchant mill, and James Thompson & Co.'s mill for the manufacture of linen twines and yarns, cotton mosquito-netting, and buckram. The last-mentioned concern has 15 feet fall, 300 horse-power of wheels, and is usually short of water about one month in the year.

Slack-water extends 1 or 2 miles above Valley Falls, and thence to Johnsonville there are occasional riffles, but it is not considered that there is sufficient fall to constitute another privilege of any importance.

The next power is principally owned by the Johnsonville Ax Company, that concern being responsible for five-sixths of the repairs on the dam. The remaining share is in some dispute, but 1,000-spindle power is certainly reserved to J. H. Aiken, who runs a small grist-mill and cider-mill. The Johnsonville company is a large manufacturer of axes, of which it turns out from 10,000 to 12,000 dozens per year, and of various other tools such as hatchets and adzes, the production of which is about the same in number as of axes. This company has 4 water-wheels running under a head of 8 feet, and besides its tool-works carries on a small grist-mill. The dam is a log structure 450 feet long and ranging from 3 to 8 feet in height. It rests on rock throughout, was built some twenty-five years ago, and was largely repaired about 1880 or 1881. Although it forms a pond nearly a mile long, this is insufficient fully to store the night-water, even in the very lowest stage of river. In the dry season the ax factory is occasionally a little short of water, and in winter there is sometimes a short stoppage on account of anchor-ice. The extreme freshet-depth on the dam is stated to be probably not over 3 or 4 feet.

Ascending the stream toward Eagle Bridge the course is found to lie through meadows, and there is a fair current, but only moderate fall. The valley is open, with long, partially-wooded side slopes. At Eagle Bridge the main river is 130 feet wide, and a short distance above the crossing displays rock in one bank, while below are short rapids over a gravelly bed; the left bank is well suited to canal and buildings. The Owl kill comes in at Eagle Bridge, and in the lower part of the village of Hoosac Falls the main river is joined from the east by the Walloomsac, an important tributary and presenting near its mouth a fine unoccupied site, formerly utilized by a mill, which was burned.

The next improved power to be noticed on the Hoosac river is at Hoosac Falls, and is utilized by the very extensive works of the W. A. Woods Mowing & Reaping Machine Company. The manufacturing works, exclusive of the lumber-yard, occupy a wedge-shaped plot of ground three-quarters of a mile long, and a quarter of a mile wide at the base. The company employs 1,600 hands, and in 1881 turned out 46,000 machines. The river here descends over massive rock ledges, and at the top of the falls there is a low horseshoe-dam, part log and part framed. One water-wheel is used, rated at 300 horse-power, and run under a fall of 19 feet. There is at times a shortage of water in summer and steam has to be used. Trouble is also sometimes experienced in winter; the pond above the dam is shallow, and in extremely cold seasons freezes almost solid.

The next power is at North Pownal, Vermont, and is utilized by the fine mill of the North Pownal Manufacturing Company, running 50,000 spindles and 400 looms on print-cloths. The dam is a log affair, said to be a hundred years old; it measures 140 feet in length, and 22 feet in height from the foundation. Water is carried 125 feet to the mill through two 8-foot trunks, and used under a head of 17 feet. There are three water-wheels, each of 165 horse-power; only two are ordinarily used, the third being reserved for high water, when the head is reduced. For about nine months in the year these wheels can be run at full capacity, and in November, 1882, were being run at about one-half capacity, the stream being at that time very low. In September of the same year a new bulkhead was being put in at the dam, when a sudden and violent freshet destroyed the temporary works and carried away 30 feet of the mill.

From Hoosac Falls to Pownal, and above to Williamstown, an entire distance of about 15 miles, the fall of the stream does not appear to be fully taken up, and there is thought to be some further opportunity for manufacturing. The stream is in this section generally bordered by meadows, and is a succession of pools or stretches of smooth water separated by riffles over gravel shoals.

Above North Pownal the first use of power is by the Hoosac Valley Knitting Company, at South Pownal. One wheel, of probably 50 or 60 horse-power, is run under a fall of 9 feet. Two thousand spindles are operated in the manufacture of hosiery, shirts, and drawers.

At Williamstown, Massachusetts, the Hoosac is from 90 to 100 feet wide, and is utilized by the Williamstown Manufacturing Company, running 17,000 spindles and 378 looms on print-cloths. This company has 14 feet fall and 472 horse-power of wheels, which, as was stated, it had been able to run continuously from December, 1881, to July, 1882. The dam is in two sections, running to an island, and is in part framed and in part built of logs. Water is conveyed to the mill in a race several hundred feet long. The mill-ponds on this portion of the stream are usually small; that at Williamstown, the mill superintendent stated, could probably be drawn down by the wheels in three hours if not supplied from the stream.

The next manufacturing village is Blackinton, where the South Blackinton Woolen Company uses 12 feet of fall and runs 18 sets of machinery on fancy cassimeres. The company has one 54- and one 60-inch American turbine, which can be run at full power about three months in the year. The dam is a log and stone crib-work built on a rock foundation. Both head- and tail-race are long, and the former troubles seriously at times in winter by freezing solid. Much difficulty is also experienced with anchor-ice.

The Greylock Mills are next in order, with 6,800 spindles and 300 looms for the manufacture of fine ginghams. The dam is of stone in cement, 210 feet long. A 5-foot Swain and a 4-foot Hunt wheel are run under a fall of 17 or 18 feet. The supply of water is sufficient for full power about half of the year, but the remainder of the time steam is used as auxiliary.

The last power on the main river is at the village of Braytonville, in the town of North Adams, and is occupied by the North Adams Manufacturing Company, running 12 sets of cards on fancy cassimeres. The dam is about 190 feet long and 12 feet high. Here, as has been noticed farther down its course, the stream is bordered by meadows and long races are necessary. At this privilege the head-race is from three-eighths of a mile to a half-mile long and the tail-race is about a quarter of a mile long. A fall of 20 feet and 125 horse-power are in use. This amount of power is stated to be obtained about eight months in the year, but at times in the dry season the amount falls as low as 40 or 50 horse-power for several days in succession.

Summary of the principal water-privileges on the Hoosac river below North Adams (in order passing down stream).

Locality.	Firm.	Manufacture.	Fall.	Horse-power of wheels in use.	Remarks.
			Feet.		
Braytonville	North Adams Manufacturing Company.	Fancy cassimeres	20	125	12 sets of cards. Can run full capacity by water-power eight months in the year.
Greylock	Greylock Mills	Fine ginghams	17–18	325	300 looms; 6,800 spindles. Use steam as auxiliary power half the year.
Blackinton	South Blackinton Woolen Company.	Fancy cassimeres	12	180	18 sets of cards. Runs at full capacity by water-power three months in the year.
Williamstown	Williamstown Manufacturing Company.	Print-cloths	14	472	17,000 spindles; 378 looms. Pond alone would carry mill not over three hours. Uses steam a large part of the year.
South Pownal	Hoosac Valley Knitting Company.	Hosiery, shirts, and drawers	9	50–60	Runs 2,000 spindles.
North Pownal	North Pownal Manufacturing Company.	Print-cloths	17	330	Extra wheel of 165 horse-power is used in high water. Company runs 50,000 spindles and 400 looms.
Hoosac Falls	W. A. Woods Mowing & Reaping Machine Company.	Mowers, reapers, etc	19	300	Very extensive works. Employs 1,600 hands, and turned out 46,000 machines in 1881.
Johnsonville	Johnsonville Ax Company	Axes, hatchets, adzes, and other tools; also runs a small grist-mill.	8	200 ±	Manufactures 10,000–12,000 dozen axes per year, and an equal number of other tools.
Do	J. H. Aiken	Runs a small grist-mill and cider-mill.			Owns 1,000 spindle-power.
Valley Falls	Valley Falls Paper Manufacturing Company.	Straw wrapping-paper	15–16	540	Permanent power thoroughly utilized, and mills short of water in the dry season from a few days to a month or more.
Do	Valley Falls Knitting Mills	Knit underwear			
Do	Harrington & Crapo	Operate a 5-run custom and merchant mill.			
Do	James Thompson & Co	Linen twines and yarns, cotton mosquito-netting, and buckram.			
Shortly above Schaghticoke.	Schaghticoke Powder Company	Powder	8	158	
Do	do	do	6½–12	50	
Schaghticoke	Wiley & Button	Straw wrapping-paper	8	600 ±	Large proportion of power not utilized. See description of powers at Schaghticoke and below.
Do	Cable Flax Mills Company	Twines, yarns, shoe-threads, etc.			
Do	do	do	7½		
Do	Unoccupied		24½		
Do	Schaghticoke Woolen Mill	Fancy cassimeres	30–34		
Do	D. Ewart	3-run grist-mill			
Do	Unoccupied		23		
Below Schaghticoke	do		23 ±		

At North Adams the main Hoosac divides into the North and South branches; each of these supports a large amount of manufacturing, and will be separately described.

The *North branch* at North Adams runs with rapid descent through a narrow and rugged valley. Its bed is of solid rock or is covered with gravel and bowlders, and it seldom exceeds 50 or 60 feet in width where running freely. On neither branch of the Hoosac are the dams an important feature, they being generally of moderate length and height, built variously as stone or timber structures. Aside from that contained in a small reservoir in the upper waters, the amount of water ponded is small, and it was stated that on the North branch probably no mill could be run more than 3 hours on its pondage alone. The chief dependence of the stream in the dry season is on the Clarksburg reservoir some 2½ miles above North Adams. It now flows 44 acres, and can be drawn down about 8 feet from full-water line. It is controlled by an association of the mill-owners, and for four weeks will keep up the supply needed at Briggs' mill, the uppermost in the village. It is practicable to enlarge this reservoir to 156

acres, with opportunity to draw it down 22 feet from full-water line, which would insure to Briggs' mill 80 horse-power, on a fall of about 27 feet, for 100 days in the dry season. It is said that there are also other places on the upper waters of this branch where small reservoirs of from 25 to 50 acres could be constructed.

From the Clarksburg reservoir down to the crest of Briggs' dam there is stated to be 100 feet or more of fall, more or less completely taken up in several unimportant grist- and saw-mill powers. Thence to the mouth of this branch the privileges are, in order, as given below. The figures for fall are kindly furnished by Mr. Briggs, and were determined by careful leveling; in some cases there is a slight variation from figures given by the different mill superintendents, but it is not important, and is very likely accounted for by the use of flash-boards.

Water-privileges on the North branch of the Hoosac river, in North Adams (in order passing down stream).

Firm.	Manufacture.	Fall.	Horse-power of wheels.	Remarks.
		Ft. in.		
Briggs Brothers	Fancy cassimeres	27 4	125	8 sets of machinery; 140 hands. Production 30,000 yards per month. Can run at full capacity by water-power about 8 months in the year. Under ordinary circumstances the power would not fall below one-half capacity, even in a very low stage; but on account of the small pondage here, and the holding back of water at uncertain times by the mills above, the flow is very irregular, and the power sometimes runs as low as 15 or 20 horse-power.
Privilege owned by Gallup & Houghton	Unimproved	40 0±		
Gallup & Houghton (Beaver mill)	Print-cloths	25 8	206	152 hands; 10,000 spindles; 232 looms.
Glen Woolen Company	Fancy cassimeres	14 2	97	100 hands; 8 sets of machinery.
Arnold Print Works (Eclipse mill)	Prints	36 4	300	164 hands; 300 looms; 12,000 spindles. Have also a 300 horse-power engine. Can run by water-power alone four months in the year.
Do	Unused	20 0		
Freeman Manufacturing Company	Printing-works	11 7	60	
Freeman Manufacturing Company (Eagle mill)	Print-cloths	25 5	270	Steam used for auxiliary power from three to nine months in the year, according to the mill. At the three mills there are run, in the aggregate, 17,000 spindles and 295 looms.
Freeman Manufacturing Company (Estes mill)	do	15 5	60	
Freeman Manufacturing Company (Stone mill)	do	13 9	35	
R. L. Jones leases privilege from Arnold Print Works.	Satinet warps and cotton towelings.	9 5	55	Runs 1,100 spindles. Considers steam principal power.

The *South branch* runs with less rapid fall and through a more open valley than the North branch, and between North and South Adams is bordered by extensive meadows. It is supplied in the dry season from what is known as the Cheshire reservoir, lying in the town of that name. This is estimated to contain from 600 to 700 acres, and can be drawn down 7 or 8 feet from full-water line. It fills regularly in the spring, and is drawn upon for from five to eight months. The reservoir is controlled by an association of the mill-owners. The flowage could not be increased, it is said, without a large expense in raising the Pittsfield and North Adams railroad track, which is close at hand. The manufacturing on this branch is mainly at South Adams, and some data concerning the various privileges in use will be found in the accompanying table. Above Adams' mill, the uppermost mentioned, there is reported to be a tannery, in Cheshire, but probably no other powers are in use, at least none of importance. At South Adams all the principal mills rely upon steam more or less of the year for auxiliary power.

Principal water-privileges on the South branch of the Hoosac river (in order passing down stream).

Firm.	Manufacture.	Fall.	Horse-power of wheels.	Remarks.
South Adams and vicinity.		*Feet.*		
J. S. Adams	Cotton goods	16	110	Owns 32 feet of fall, but uses only 16. Runs 5,000 spindles.
H. S. Millard	do	19	75–80	5,200 spindles.
B. F. Phillips & Son	Fancy cassimeres and ladies' dress goods.	13	92	7 sets of machinery. Can run at full capacity by water-power not over eight months in the year.
Adams Brothers & Co	Cotton warps	16	80	3,600 spindles.
Renfrew Manufacturing Company	do	13	70	8,196 spindles.
Plunkett & Wheeler	Cotton warps	19–20	125±	3,500 spindles.
L. L. Brown Paper Company	First-class ledger papers	11½	100	The mills together produce 7,340 pounds of paper per day and give employment to about 175 hands. At the lower mill there are two wheels supplied from the same level, under 11 and 13 feet fall, respectively.
Do	do	11–13	144	
Renfrew Manufacturing Company		7		
W. C. Plunkett & Sons	Cotton warps	15	130±	2,500 spindles.
Renfrew Manufacturing Company	do	15	145	4,320 spindles.
Do	Ginghams	18	290	Can run wheels at full capacity not over two months in the year. Splendid mill, with 1,000 looms and 16,876 spindles.
Do	Cotton warps	8½	40–50	1,200 spindles.
North Adams.				
M. D. & A. W. Hodge	5-run grist-mill	10	60	
Johnson Manufacturing Company	Ginghams	16	195	300 looms; 9,000 spindles.

FISH CREEK.

The principal source of this stream is in Saratoga lake, whence it flows with an indirect easterly course, about 8½ miles in length, to the Hudson river, which it joins at Schuylerville. Through Kayaderosseras creek, the chief tributary of the lake, the drainage area of the main stream is extended over the whole of central Saratoga county, and at the junction with the Hudson includes 253 square miles. Though often described as of larger dimensions, Saratoga lake is represented on French's map of New York state as 1⅝ mile wide in the broadest part, and as having a length of 4½ miles in the main portion, increased by a narrow arm to about 6½ miles; the area thus covered is 5.6 square miles. The country about the lake is flat or gently rolling, and toward the outlet is low and marshy. The uppermost dam on the outlet is at Grangerville, distant 4½ or 5 miles from the extreme terminus of the lake, and so far removed from the latter that it is said to have no influence, of importance at least, upon the storage. The lake rises in spring, and then gradually falls, through the natural drainage of the outlet, and at times there is scarcely any water running in Fish creek. The fall is slight in the latter till it reaches Victory Mills, a mile and a half or more from the mouth, but below that point there is quite a rapid descent, which is pretty thoroughly utilized for power. In this part of its course the banks are much of the way bold and steep, and both they and the bed are composed of slate and shale dipping to the southeast. In its lower course the creek averages from 60 to 75 feet in width. It carries some anchor-ice in winter, but seldom freezes over. The lake holds back freshet water, so that little inconvenience is occasioned from that source, but some trouble is at times suffered at the lowest privilege from backwater, due to freshets in the Hudson. In April, 1869, there is said to have been an unusually heavy freshet both in Fish creek and in the Hudson, the former rising above its banks at Schuylerville and well up into some of the mills.

The first privilege above the mouth is at the village of Schuylerville, and is owned by Messrs. D. A. Bullard & Sons, with the exception of a small power belonging to Craw & Dennis, utilized in a foundery and machine-shop. The dam is of stone in cement, from 130 to 140 feet long, with a vertical face from 7 to 9 feet high, the back slope being planked over; it rests upon rock, and presents an angle up stream. The race is open for 25 feet, and then passes underground the rest of the way to the mills. The fall obtained ranges, according to position on the race, from 14 to 18 or 20 feet. The principal use of power is by the Messrs. Bullard in the manufacture of writing- and printing-papers and card-board, their production amounting to 4 tons per day. Besides the works already noticed there are also operated on this privilege a 5-run grist-mill and a small sash and blind shop. Altogether about 370 horse-power of wheels is in use. For one or two months in the year there is a scarcity of water, but the paper-mill has steam for auxiliary power, and has never been forced to shut down from low water for more than a few hours at a time.

Close by, the Bullards own a privilege on the Champlain canal, utilized by a saw-mill, and which is of interest as having once been owned, and the saw-mill run, by General Schuyler, whose former residence is yet standing on the opposite bank of the creek.

Below the paper-mill tail-race there is a fall of about 3 feet to the Champlain canal aqueduct, which will be made available at the mill by dredging the channel. There is also said to be a further fall, in an ordinary stage, of some 4 feet down to the mouth of the creek.

Above the Bullard privilege the greater part of the land along the creek and all the utilized powers are owned by the Saratoga Victory Manufacturing Company. This company has two mills—the Horicon mill, at Schuylerville, with 10,060 spindles and 264 looms, and the Victory mill, about a mile above, with 29,000 spindles and 611 looms. The manufacture comprises silesias, cambrics, bleached goods, and wigans, and amounts to about 6,000,000 yards per year. Steam is used for auxiliary power, there being a greater or less shortage of water during three or four months of the year, and at times it is said that there is hardly enough water for turning the shafting in the mills. The Horicon privilege immediately succeeds that owned by the Bullards, and includes 24 feet fall. The dam is a straight timber structure resting upon and abutting against solid rock. It is 19 feet high, the face nearly vertical. The race leads underground perhaps 300 feet to the mill, where power is taken from a 160 horse-power wheel.

At Victory Mills the dam is also of timber, rests upon a ledge, and is about 140 feet long and 8 feet high. Water is conveyed in a race 500 feet, more or less, and operates an 800 horse-power Holyoke wheel, running under a head of 40 feet. Only about 600 horse-power, however, is actually in use. The wheel-pit is sunk 30 feet into solid rock. The tail-race extends thence 170 feet through a tunnel 13 feet wide and 7 feet high, and then 500 or 600 feet farther in an open channel.

Above Victory Mills the stream is quite flat, with no dam except at Grangerville, where about 14 feet fall is owned by the Victory company and utilized by a saw- and grist-mill. Both above and below Grangerville there are occasional rifts where the water is shallow; and in order to drain as thoroughly as possible the pools or deep stretches above them, the Victory company has run canals around the rifts, and by means of head-gates controls the flow.

THE BATTEN KILL. (*a*)

This is one of the best mill-streams tributary to the Hudson. Its sources are in the southwestern part of Vermont, in the towns of Peru, Dorset, and Winhall, Bennington county. At first the stream runs southwesterly,

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a Kill (Dutch *kil*) is the equivalent for "river" or "stream".

but it then strikes more to the westward, and with a very irregular course crosses Washington county, New York, entering the Hudson a mile above Schuylerville. It has a length from source to mouth, by general course, of about 45 miles, and a drainage basin of 457 square miles. This basin lies on the western slopes of the Green mountains, and in Washington county is crossed by three minor ranges running northeast and southwest—the Cossayuna range, the most westerly, passing through the towns of Easton, Greenwich, and Argyle; while to the east are met, successively, continuations of the Petersburg mountains and Taghkanick range, of Rensselaer county. These ranges have steep slopes, are composed of slate rock, which frequently crops out and is largely quarried, and the disintegration of which has given the highlands a very fertile soil. In the eastern part of the county the highest summits reach altitudes of from 1,000 to 1,200 feet above tide. The agricultural productions of this section comprise rye, spring wheat, oats, buckwheat, corn, peas, beans, flax, and potatoes. Stock-raising, dairying, and wool-growing are prominent industries.

As might be expected from the nature of the country drained, the Batten kill is subject to quite heavy freshets and runs of ice, but its current is rapid and high water quickly subsides. It is very largely fed by springs, so that the dry-season flow is well sustained. It is a common opinion that the flow might still further be improved by storage reservoirs, to which the upper waters of the main river and its tributaries are thought to be favorable. In particular there are mentioned two large ponds the waters of which reach the river 1½ or 2 miles above Battenville through Cossayuna creek. The principal one of these is known as Cossayuna lake, and is nearly 3 miles long, and over half a mile wide in the broadest part. It lies on the boundary between Greenwich and Argyle towns, and above there is another of good size, called Gifford's pond, the two being connected on nearly or quite the same level. There is a small mill at the outlet of Cossayuna lake, and it is stated that the dam at that point can be raised several feet, thus giving a splendid storage above. The tributary drainage area at the outlet of Cossayuna lake is approximately 9 square miles, and the average annual rainfall on this area is about 38 inches.

The immediate course of the river is through a fertile and well-settled valley, with numerous small villages, of which the most important is Greenwich, having 1,200 inhabitants. Railroad facilities are somewhat deficient, the lines which reach this section running at right angles to the general course of the stream in its most important portion. The upper river, however, above the village of Arlington, Vermont, is followed to the head by the Bennington and Rutland railroad, and the Rutland branch of the Delaware and Hudson Canal Company's railroad follows the middle course for about 4 miles. From Greenwich, on the lower river, a short line runs southerly, connecting with the Hoosac Tunnel route for points east and west.

According to the Delaware and Hudson Canal Company's profiles, the water-surface of the river, at the crossing a little south of Shushan, is 432 feet above mean-tide at Albany, or about 437 feet above mean ocean-level. Judging from the best data to be obtained, the elevation at the mouth of the river may be placed at about 82 feet above mean ocean-level, though this amount is liable to be slightly in error. There is, then, a descent of about 355 feet in the intervening distance of 22 miles, or an average of say 16 feet per mile. Very nearly, and perhaps quite, one-half of this, however, is concentrated within the last 4 or 5 miles of the river's course, and since the volume is there the greatest the value of the Batten kill for power is greatly enhanced by the fact.

The first water-privilege met in ascending the stream is but a short distance above the mouth, at a place locally known as Clark's Mills. The river there runs between banks and over a bed of black slate rock, is about 250 feet wide, shallow, and contains rapids with moderate fall for 800 or 1,000 feet below the dam. The privilege is owned by Hiram Clark, and is utilized on the north bank in the manufacture of sashes, doors, and blinds, a saw-mill and plaster-mill also being run in connection with the other works. A log dam, 9 feet high, runs across to a ledge on the south bank. The fall obtained at the mills is 10 feet. There is at times a little scarcity of water, but it is due to the very leaky condition of the dam, and even in its present condition the proprietor counts upon 100 horse-power in the very lowest stage of the river. Once in three or four years some hinderance is experienced for perhaps a week, due to backwater from the Hudson. In the spring break-up gorges form at the head of the pond, and when they go out cause a very heavy run of ice.

Clark's pond sets back not over half a mile, and is succeeded by rapids on to the foot of the "Big falls". The immediate course of the stream is bordered by narrow meadows, from which there is a moderately steep rise of possibly 100 feet to the general level of the surrounding country, below which the valley is depressed. For a part, at least, of this intervening distance the adjacent land is included in the estate of Barant B. Lansing.

Next in order comes the power at the "Big falls", the Indian name of which was Dionondahowa. When visited, the privilege was being developed by its owner, Mr. W. N. Sprague, of Middle Falls, and a splendid power had easily and with remarkable cheapness been obtained. The locality is about 2½ miles by direct course from either Schuylerville or Greenwich. A bridge is contemplated near the dam, which will give a direct and convenient route to Schuylerville, and it is claimed that a railroad can, and probably will, be run here from Greenwich. At the former of these points the Champlain canal will be reached, and at either one connection can be obtained with the Boston, Hoosac Tunnel, and Western railroad. Below the head of the falls the stream rapidly cuts its way down into the slate rock, the strata of which are almost vertical, and forms a deep gorge with precipitous sides. It descends into a quiet pool, and then continues on through the gorge with moderate

fall. At the head of the falls, where the dam is located, the stream runs north, the west bank is high and rocky, while the east is gently sloping and succeeded by fine open ground, which also extends down some distance and affords good building-sites. The dam abuts at the west end against the rocky bank, and at the east end has a masonry abutment 14 feet long, from 4 to 6 feet wide, and rising 4 feet above the crest. In construction the dam is a log crib-work filled in with stone and pinned down to the solid ledge rock on which it is built. The roll way or overflow is 265 feet long, and ranges in height from 7 to 12 feet, according to the contour of the rock. It was built with 2½ base to 1 vertical, so that where of the full height of 12 feet the width at base is about 30 feet. The bulkhead is of timber, and has a length, transversely to the current, of 25 feet. From it a canal runs down the east bank, 2,800 feet long, 25 feet wide, and 7 or 8 feet deep. It is partly in rock excavation, and in its course enters a natural depression, where it is to be diked on either side.

The entire descent from the crest of the dam to the pool below the falls is 106 feet, which is to be used in five successive falls of 13, 18, 20, 25, and 30 feet, respectively. The Ondawa Paper Company has purchased the lower fall of 30 feet and erected a mill 210 by 60 feet in size, for the manufacture of manila paper, with a capacity of 4 tons per day. The mill has been built directly on the brink of the river-bank, which is here high and very steep. The entire 30 feet is used in one fall. Water enters two upright wooden pen-stocks, cylindrical in shape, measuring 9 feet in outside diameter. The bottoms are of oak and the sides of 3-inch chestnut. On the outside are hoops of round iron, increasing in diameter from three quarters of an inch at the top of the cylinders to 1 inch at the bottom, and decreasing in distance apart similarly from 2 feet to 3 inches. The planks composing the sides are in four unequal lengths, breaking joints. In order to secure tight joints, the ends of the planks are sawed into, a little way, and pieces of hoop-iron inserted.

In November, 1882, the work on the race was well advanced. There was a small saw-mill at the dam, and that, with the paper-mill, were the only buildings which had been erected. Mr. Sprague owns 133 acres of land here, and is prepared to lease, or otherwise dispose of, to manufacturers, sites and power to the full capacity of the privilege, excepting, of course, the 30 feet fall already sold to the paper company.

Estimate of power available at the "Big falls" on the Batten kill.

Stage of river.	Rainfall on basin. Spring.	Rainfall on basin. Summer.	Rainfall on basin. Autumn.	Rainfall on basin. Winter.	Rainfall on basin. Year.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 foot fall. (a)	13 feet, upper fall, not used.	18 feet, second fall, not used.	20 feet, third fall, not used.	25 feet, fourth fall, not used.	30 feet, fifth fall, used.	76 feet, total fall not used.	106 feet, total fall on privilege.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. m.*	*Cu. ft.*								
Low water, dry year							180	20.45	270	370	410	510	610	1,560	2,170
Low water, average year	9	11⅓	9½	8	38	454	200	22.72	300	410	450	570	680	1,730	2,410
Available 10 months, average year							280	31.81	410	570	640	800	950	2,420	3,370

a Mr. Sprague, the owner of the privilege, estimates 30 effective horse-power per foot of fall available twenty-four hours in the day, eleven months in the year, or twelve hours per day throughout the year.

From the privilege just described up to that at Middle Falls there is said to be about 10 feet of fall available for power, and owned by Messrs. David C. Fielding and Nathan Tefft.

At Middle Falls, a small village, the river again descends abruptly over ledges, and below winds through extensive meadows. Just above the dam the width between banks is about 175 feet. The dam itself is at the head of the falls and measures 135 feet between abutments, and varies from 12 to 16 feet in height above foundation; it is built as a log crib-work.

The total fall on this privilege is 47 feet. Mr. W. N. Sprague owns the power on the right bank, and employs it in the manufacture of wood-pulp and leather-board. The water is used in two successive falls, being first carried 80 feet from the dam and used under a head of 20 feet, running three wheels of 250 aggregate horse-power. It is then carried 60 feet farther, and runs a 150 horse-power wheel, acting under a head of 27 feet. It is designed so to enlarge the works as to employ the full power of this second fall. During the very dry summer and fall of 1882, all the wheels mentioned could be run at full capacity twelve hours per day, and twenty-four hours per day except on eleven days, when they were run varying periods between twelve and twenty-four hours. On the left bank Cipley & Hegeman have a 5-run flouring- and grist-mill, a plaster- and cement-mill, and a small saw-mill. They use a fall of 17 feet, and six wheels with a total of 135 horse-power. H. R. Richardson rents 200 square inches of water under 12 feet head. He has an old 30-inch Rich wheel of perhaps 30 horse-power, and manufactures cattle-hair horse and army blankets, turning out about 6,000 pounds per month.

Estimate of power at Middle Falls.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*47 feet fall.*	
Low water, dry year	450	180	20.45	960	500–600
Low water, average year		200	22.72	1,070	
Available 10 months, average year		280	31.81	1,500	

The Middle Falls dam sets back the river for about a mile and a quarter; thence to the lower dam at Greenwich there are occasional riffles, but no fall occurs of any consequence. In the vicinity of Greenwich the surrounding country is to a large extent very flat, though in places diversified by hills. The village is a fine and important one, and within its limits the Batten kill sustains quite a manufacturing interest, being utilized in three falls.

The first privilege met in ascending is occupied by Dunbar, McMaster, & Co., a branch house, of which the main establishment is at Guilford, Ireland, and the mills are known as the Dunbarton Flax Mills. The production comprises linen threads, yarns, and fine twines, and amounts to nearly a ton per day. The flax used is mostly imported, but 200,000 pounds per year of the American material are also worked up. A great deal of flax is raised in this part of New York state, notably in Washington and Rensselaer counties. The dam at this privilege is a log and stone crib-work, probably 200 feet long and about 8 feet high. There is a masonry abutment at the north end, from which it runs diagonally across the stream to a rock ledge. It has a sloping timber apron, 25 feet wide half-way across and about half that width the rest of the distance. A covered timber flume, 5 by 12 feet in inside dimensions, conveys water to the wheel, which is rated at about 130 horse-power and runs under a head of 11½ feet. The water-power is, for some reason, not fully utilized here, even in the lowest stage, and steam is constantly used in part for power. The ordinary freshet depth on the dam is stated as not far from 3 feet. Some trouble is experienced from backwater due to freshets, which have at times set up into the dye-house of the mill; and also from that due to ice-gorges in the river below, by which a day's stoppage is sometimes forced.

The next privilege quickly succeeds, and is improved by a framed dam built on a rock ledge. This dam is 200 feet or more in length, about 9 feet high, and was built 10 or 12 years ago at an estimated cost of $4,000. The top, for 40 inches back from the crest, is shod with ¼-inch boiler-iron. On the north or right bank, two-thirds of the entire flow of the river, less 228 square inches reserved, is owned by W. M. Palmer, and used in part for a 6 run grist-mill and a small saw-mill under a fall of 10 feet. The 228 square inches, under a fall of 10 feet, is stated to be owned by Gray & Mowry, who rent the power for a small batting-mill. On the south bank the remaining one-third of the power is owned by W. Eddy & Sons. A 100 horse-power wheel, under a fall of 12 feet, supplies power for dressing flax and for a small shirt factory.

The upper privilege is improved by a framed dam some twenty years old; this is 5 or 6 feet high, rests upon a rock ledge, and has masonry abutments. Water is admitted through a wooden bulkhead with four gates to the race, and passes thence a short distance to the mills. The privilege is owned by Messrs. Jesse V. & William B. Palmer, who use part of the power in the manufacture of knit underwear; 1,040 spindles are run by a 70 horse-power wheel operating under a fall of 7½ feet. Angell & Safford rent 800 square inches of water from the Palmers for the manufacture of brown hanging-papers, of which their production is 3,200 pounds per day. They have 7½ feet of fall and a 60 horse-power wheel.

Above Greenwich village there are occasional riffles up to Center Falls. There the river descends over ledges, falling about 25 feet in 700 or 800 feet. The banks are rocky and rise from 15 to 40 feet above the stream. The exposed rock is a slate, dipping about 45 degrees to the westward. At the head of the falls are the partial remains of an old log dam, from which water was formerly carried down the right bank in a race and used at mills that were afterward burned. The privilege is a fine one, 2 or 2½ miles above Greenwich, and is said to be owned by Mr. Daniel A. Bullard, of Schuylerville. The fall to be obtained depends upon the height of the dam, but probably there would be no difficulty in realizing 30 feet.

Estimate of power at Center Falls.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*25 feet fall.*	*30 feet fall.*
Low water, dry year	9	11½	9½	8	38	418	160	18.18	450	550
Low water, average year							180	20.45	510	610
Available 10 months, average year							260	29.54	740	890

At Battenville, 1¾ mile above, there is a very old log dam, ponding the water for about a mile up stream. It rests partly on rock, partly on quicksand, and is irregular in shape, with a sloping plank apron and a supplementary embankment at each end. The fall on the privilege is 9 feet. The available supply of water is put nominally at 1,400 square inches, of which one-sixth is owned by W. D. McLean, one-third by Nicholas Miller, and one-half by Mowry & Hobbie, who use the power, respectively, for a saw-mill, a 4-run grist-mill, and a straw wrapping-paper mill with a production of 2½ tons per day.

A mile and a half above Battenville, Cossayuna creek joins the main stream from the north. From Center Falls to Battenville the immediate valley is rather narrow, but thence up to East Greenwich, about 3 miles, the hills recede and the stream is bordered by meadows, which are much of the way very extensive. At East Greenwich the Batten kill is from 70 to 80 feet wide. The dam at that place is an old structure, about 210 feet long and 7 feet high, resting part of the way on rock and the remainder on loam and clay. The head realized is 7 or 7½ feet. On the south bank W. & A. Walker employ 20 hands and a 40 horse-power wheel in the manufacture of army blankets, and a small power is also used in a sash and blind shop. On the north bank there are a saw-mill and a 4-run grist-mill.

Just above East Greenwich, Black creek, quite an important tributary, empties from the north. The next use of power is at Baxterville, where the Vermont Marble Company employs 7 feet fall in sawing marble, which is brought there 55 miles by rail from West Rutland. An average of 75 saws is run, and about 30,000 cubic feet of marble are annually sawed. The dam is a log and stone crib-work, with a sloping apron, is 7 feet high and perhaps 150 feet long. The pond is said to extend about a mile up stream.

At Shushan, about 21 miles by river from the mouth, there is a log and stone crib-work dam, which was partially carried away some 15 years ago, and which affords a head of 7 feet. The establishments using power are small, and comprise a foundery, a saw-mill, a 5-run grist-mill, a 1-set woolen-mill for the manufacture of cassimeres and flannels, and a shirt factory. In low stages the supply of water is insufficient for the needs of these works, although the night-flow of the stream can then be ponded.

Above Shushan the Batten kill is described as having only moderate fall, and as running for a considerable distance through meadows, which it overflows in freshets. Powers are said to be in use all the way up toward the head, but they are of small size. Quite a large amount of timber used to be floated down the stream, and some is still driven to the mills which have been noticed, mainly spruce and hemlock. The drainage area above Shushan is 240 square miles.

Summary of the principal water-privileges on the Batten kill below Shushan.

Locality.	Approximate distance from mouth. (a)	Drainage area.	Manufacture, or kind of mill.	Fall.	Theoretical horse-power. Low water, dry year.	Low water, average year.	Available 10 months, average year.	Horse-power of wheels in use.	Remarks.
	Miles.	Sq. miles.		Feet.					
Shushan	21	240	Foundery, saw-mill, 5-run grist-mill, 1-set woolen mill, and shirt factory.	7				120	Shortage of water in low stages, though the night-flow can then be ponded.
Baxterville			Power used by the Vermont Marble Company for sawing marble.	7				24	75 saws run, and about 30,000 cubic feet of marble sawed yearly.
East Greenwich	13½	389	Power used in saw-mill, grist-mill, sash and blind shop, and in the manufacture of army blankets.	7-7½				(?)	20 hands employed in the blanket-mill.
Battenville	11	410	Power used in saw-mill, grist-mill, and paper-mill.	9				175±	The paper-mill manufactures straw wrapping-paper; production, 2½ tons per day.
Center Falls	9	418	Not utilized	30±	550±	610±	890±		Fine privilege; natural fall of 25 feet in 700 or 800 feet; rocky bed and banks.
Greenwich	6½	438	Knit underwear and hanging-paper.	7½				130	1,040 spindles in knitting-mill. Production of paper-mill, 3,200 pounds per day.
Do			Power used in grist mill, saw-mill, batting-mill, shirt factory, and for dressing flax.	10-12				(?)	Dam 200 feet or more long, 9 feet high, built 10 or 12 years ago, and cost say $4,000.
Do			Linen threads, yarns, and twines.	11½				130	Production nearly a ton per day.
Middle Falls	4	450	Wood-pulp, leather-board, and cattle-hair blankets; power also used in saw-mill, plaster- and cement-mill, and flour- and grist-mill.	47	960	1,070	1,500	500-600	
From Middle Falls to the Big falls.			Not utilized	10±	200±	230±	320±		Said to be owned by D. C. Fielding and Nathan Tefft.
Big falls	2	454	Recently developed, and but partially utilized as yet.	106	2,170	2,410	3,370		See description.
From the Big falls to Clark's Mills.			Not utilized	(b)	c 20.45	c 22.72	c 31.81		
Clark's Mills	½		Power used in sash-, door-, and blind-shop, saw- and plaster-mill.	10				(?)	Occasional trouble from Hudson river backwater and from ice-gorges.

a By river. b Moderate amount. c Per foot of fall.

THE SACONDAGA RIVER.

This river, which ranks second below the Mohawk among the tributaries of the Hudson, in extent of area drained, is made up by three principal branches, which unite in the southeastern part of Hamilton county. The East branch has its source in the town of Johnsburg, Warren county, whence it runs to the southwest; the Middle branch receives the waters of Round lake and lake Pleasant, and then takes a curving course, about 10 miles in length, to the East branch; the West branch flows easterly from Piseco lake, and joins the united waters of the other two branches in the southern part of the town of Wells. From this point the main river passes to the southeast through about 16 miles of general course, crossing the adjacent corner of Fulton county, then turns suddenly to the northeastward into Saratoga county, and gradually curving around to the eastward empties into the Hudson at the village of Hadley. In the abrupt change of course which this river makes on the border between Fulton and Saratoga counties it presents a remarkable similarity to the upper Hudson, which has a corresponding sharp bend 18 or 20 miles to the eastward. From the mouth of the West branch the distance by river to the Hudson is by map measurement 40 miles.

The water-shed lines of the Sacondaga embrace an area of 1,028 square miles, nearly all of which is a mountainous country, traversed by various minor ranges which go to make up a part of the elevated Adirondack region of northern New York. The rocks are of primitive formation, and consist largely of gneiss. The soil is a light sandy loam, and elsewhere than in the valleys apparently has little value for agriculture. The entire district was once heavily clothed with timber, the most accessible portions of which have now been cut away; and though the amount standing is still of much importance, and the Sacondaga is claimed to outrank the upper Hudson in the number of logs driven down its course, the lumbermen have been forced farther and farther into the mountains, until now their operations are mainly in the region about lake Piseco. Settlement is sparse throughout the basin of this river, and especially so above Fulton county. The most populous township along the whole stream, Northampton, has but 2,100 inhabitants, and the largest village, Northville, 800. To this latter point a railroad extends from Fonda, on the line of the New York Central railroad, but nowhere else above its mouth is the stream directly accessible by rail.

From elevations (*a*) obtained in surveys by A. F. Edwards, chief engineer of the proposed Sackett's Harbor and Saratoga railroad, it appears that lake Pleasant has an altitude of 1,706, and Piseco lake of 1,648 feet above tide. Other elevations, from the same source, on the East branch and main Sacondaga are given in the following table:

Table showing the fall in the Sacondaga river.

Locality.	Approximate distance above mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
East branch at Burnam's pond, Gilman	....	1,706			
			....	369	....
East branch at head of High falls	....	1,337			
			....	132	....
East branch at foot of High falls	....	1,205			
			....	163	....
East branch at Copeland's mill-pond	....	1,042			
			....	84	....
East branch at tannery mill pond	....	958			
			....	56	....
Main river at forks, Wells	40.0	902			
			5.2	139	26.7
Main river at Hope center	34.8	763			
			6.1	31	5.1
Main river at tannery, Northville	28.7	732			
Main river at bridge, Huntsville	12.9	697	23.1	35	1.5
Main river above dam at Conklingville	5.6	697			
			5.6	161	28.7
Main river at mouth	0.0	536			

So far as rapid fall and large volume are concerned, it is evident that the last 5 or 6 miles of the river's course, from Conklingville to the mouth, is the most valuable for power; in that distance there is a descent, as shown by the table, of 161 feet, which is accomplished quite uniformly, in rapids. About 39 feet of this fall is already utilized in three privileges, but the remainder is unimproved. Although it is, doubtless, perfectly practicable to develop nearly or quite all of the remaining fall, there are certain disadvantages to be encountered. In the first place, the composition of the river-bed and banks is variable, uncertain, and often unfavorable to the security of hydraulic works. For a mile above the mouth, the banks, while of good height, are largely composed of sand, with loose bowlders intermingled; and generally through the valley below Conklingville, so far as there was opportunity to examine, the surface materials in the vicinity of the stream were found to be very variable. The bed of the river is usually covered with gravel and bowlders, but instead of these being underlaid by solid rock, there is

a Quoted in F. N. Benedict's *Report on a Survey of the Waters of the Upper Hudson and Raquette Rivers.*

frequently found beneath a deep deposit of sand, with possibly some clay. Both the dams below Conklingville have been repeatedly carried out, and at the site of the lower one a hole 30 feet deep was in one instance scoured in the river bed. At the privilege occupied by the New York Pulp Company, perhaps 1½ mile or 2 miles from the mouth, clay is found in the tail-race, gravel and hard-pan occur near by in the bank, while bowlders, and gravel of all grades in fineness, form the surface of the river-bed, below which there is supposed to be mainly sand, a material that is also very common in the banks in that vicinity.

The Sacondaga contains a great deal of anchor-ice at the beginning of winter, and throughout the season if it be an open one, and is also visited by heavy ice-runs, although the cakes are commonly well broken up against the bridge-piers at Conklingville and in going over the successive dams there and below. Sudden and violent freshets occur, and considerable trouble is encountered from floating logs. These are not allowed to pass down when the stream is at its highest, as many of them would then be lodged upon the banks; but they are sent down when the river, though high, is well within its banks, and at the stage of water when they rake the dams the worst.

Assuming as correct the figures that have been given for the fall in the lower river, in the absence of any recorded gaugings the volume and corresponding power of that section may be estimated as below:

Estimated power of the Sacondaga river from the crest of the Conklingville dam to the mouth.

Stage of river.	RAINFALL ON BASIN. (*a*)					Drainage area.	Flow per second, average for the 24 hours.	THEORETICAL HORSE-POWER.			Approximate effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	122 feet fall, remaining undeveloped.	161 feet fall, = total descent.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*				
Low water, dry year							90	10. 22	1, 250	1, 650	
Low water, average year	9	12	11	8	40	*b* 1, 016 *c* 1, 028	120	13. 63	1, 660	2, 190	Probably 600–800.
Available 10 months, average year							200	22. 72	2, 770	3, 600	

a Roughly estimated; no data for accurate determination. *b* At Conklingville. *c* At mouth.

Excepting a limited use that is made of Piseco lake by the owners of the large saw-mills on the Hudson, the Sacondaga is not sustained in the dry season by any storage-reservoirs, though it can not be doubted that the many lakes within its basin present favorable opportunities for such improvements.

For three-quarters of a mile or a mile up from the Hudson there is a continuous rapid, with a fall estimated at 15 or 20 feet, which could be utilized near the mouth. We then come upon the privilege occupied by the Sacondaga Pulp Company, having a fall of 12 feet, the power being used for grinding poplar and spruce. The dam was built about the year 1876, and has been carried away in part two or three times since. It rests upon a sandy bed, is from 250 to 275 feet long, and has a sloping apron 30 feet wide, covered with round logs of small size laid with the slope. The structure is built of logs, filled in with stone part of the way across the stream, and is very leaky; it abuts against a ledge at one end, and next the mill against crib-work.

The second improved power closely succeeds the one just described, and is utilized by the New York Pulp Company, having 5 wheels, the combined rating of which was stated by the foreman of the mill as 425 horse-power. The dam is of logs, filled in with stone, and has twice been carried out. The first time it had merely been built up against the bulkhead without being bonded into it, and the adjacent portion was forced out. In order to pass the flow of the river while this first break was being repaired, a sluice was then cut near the center of the dam, reaching nearly to the base. There came a sudden rise in the stream, which brought down many logs; these crushed in the apron and injured the sluice; there was a heavy scour about the latter, and the section of dam farthest from the mill was swung around and carried down stream. At the time of the first failure the mill had been built out over the river and was also destroyed with the dam. It was afterward rebuilt in-shore. The present dam is 13 feet high, and with 2-foot flash-boards gives an available head of 15 feet at the mill.

From this point up there is a constant rapid, but there are no dams before reaching Conklingville, a small village between 5 and 6 miles from the mouth. The river-bed is there covered with bowlders and gravel, said to be underlaid by sand. The dam has stood some 50 years, is quite leaky, and has settled a foot or two. It has a sloping apron about 18 feet wide, and the whole is planked over; the structure is from 230 to 240 feet long, and has crib-work abutments with smooth timber facing. On the left bank a moderate power is used in Clement's wooden-ware factory, while on the right bank a race leads down several hundred feet to Henry Poor & Son's tannery, where a head of about 12 feet is obtained. In some years there is throughout a plenty of water at this privilege, while in others the supply falls short during August and September.

Above Conklingville smooth water is said to extend 20 miles up the stream, and the latter is navigated by a small steamer of 18 or 20 inches draught, used for towing scow-loads of hemlock bark. Above this flat stretch there are rapids again, and occasional powers are in use by saw-mills and tanneries. At Northville the Sacondaga has a tributary drainage area of 700 square miles.

THE SCHROON RIVER.

The extreme sources of this river are in the central part of Essex county, from 5 to 15 miles southeasterly from mount Marcy. It flows thence in a general southerly direction for about 45 miles and joins the Hudson nearly opposite Thurman station on the Adirondack railroad. In the middle part of its course, on the boundary between Essex and Warren counties, the river spreads out to form the extensive sheet of water known as Schroon lake, which is 8½ miles long and varies from half a mile to a mile and a half in width. Schroon river receives the drainage from an area of 556 square miles, almost entirely a rugged mountainous country traversed by numerous elevated ranges, once heavily clothed with forests, but now largely cleared; the soil is generally light, sandy, and poor, except in the valleys; the population is scattered, and above the mouth the river is nowhere directly accessible by railroad.

In Colvin's report on the *Survey of the Adirondack Region*, the elevation of Schroon lake is given as approximately 830 feet above sea-level; by the profile of the Adirondack railroad the corresponding altitude of the water-surface at the mouth of the river is 594 feet; from which it appears that, in the intervening distance of about 20 miles by general course, there is a fall of 236 feet.

Besides Schroon lake there are numerous other lakes and ponds within the basin of this river, most of which are said to be dammed and utilized for the operations of log-driving. Some data concerning these, contributed by Joel F. Potter, surveyor, to Benedict's report upon the upper Hudson, are given below:

Principal lakes and ponds in the Schroon River basin.

[From a report by J. F. Potter, in 1874.]

Name of lake or pond.	Surface in acres.	Remarks.
Schroon lake	4,730	There is a dam on the river, 5 miles below the outlet of the lake, which, if raised 2 feet, would flow several hundred acres above and around the head of the lake.
Paradox lake	1,520	Drains into Schroon river a mile north of the head of Schroon lake, and is on about the same level with the latter; by raising the dam, located 5 miles below the outlet of Schroon lake, 6 feet, Paradox lake would be raised at least 3 feet, and a body of water would be formed 24 miles in length, flowing, together with the lakes, 7,750 acres.
Brant lake	1,920	About 5 miles long; controlled by a dam.
Friend's lake	648	Controlled by a dam on the outlet.
Loon lake	400	It is estimated that by a dam on the outlet the capacity could be increased one-third.
Valentine pond	229	Lies in the town of Horicon, Warren county.
Lake Pharaoh	480	Raised 12 feet, and used for many years as a reservoir to supply water for driving logs.
Crane pond	338	Controlled by a dam which might be raised 20 feet.
Long pond	460	Drains to Paradox lake, and is controlled by a dam.
Mud, Clear, and Sand ponds	*a* 1,200	Lie at the head of the west branch of Schroon river, and are all controlled by dams for log-driving.
Bullpout pond	200	In the town of North Hudson, Essex county.
New pond	250	In Elizabethtown, Essex county.

a Combined area.

In considering the value of these lakes as reservoirs for storage, Mr. Benedict roughly estimates their aggregate capacity at about 5,900,000,000 cubic feet, which would insure a supply from this source of say 680 cubic feet of water per second for 100 days.

In proportion to its size the Schroon is a better stream for power than the upper Hudson. Its valley is more open and productive, better settled, and the stream itself more uniform in flow. It is comparatively well sustained in the dry season, is free from destructive freshets, carries but a moderate amount of anchor-ice, and surface-ice has very seldom been known to go out until it has first become thoroughly rotted in the ponds. The oscillations caused by rains are less rapid than in the Hudson, and it is said the latter will reach the top of a flood and begin falling before the Schroon has risen to its full height. The logging interest on the stream is still large, but an important part of the timber has been cut away, and operations are now confined to the region around and above Schroon lake.

Ascending from the mouth of the river after leaving the immediate valley of the Hudson, the Schroon becomes shallow and rapid. Gravel and small bowlders cover the bed, while the banks are of good height, and from the mouth to Warrensburg are generally gravelly or sandy in appearance. It is stated, however, that though the exterior is sandy, the banks are at a depth of a few feet composed of hard-pan. There is probably sufficient fall for one mill-privilege below Burnham's, the lowest now in use, and there is said to have been a dam many years ago at some point along this portion of the stream.

A mile and a half above the mouth and 2 miles below Warrensburg a fall of 12 feet is used by J. H. Burnham, who grinds and sells wood-pulp manufactured mainly from poplar. The dam is a log structure built about 1877. It is 100 feet long between abutments, 10 feet high, and probably 60 feet wide at the base. Of this width 27 feet is taken up by a sloping apron covered with round timber, and supported by four crib-work piers, each 12 feet square.

The proprietor claims that his dam could be raised 10 feet without overflowing the banks above to any important extent. Two wheels are in use of 75 horse-power each. For two or three months in the year there is some scarcity of water, but one wheel can always be run twenty-four hours in the day.

The next improved power is in the lower part of the village of Warrensburg, the principal settlement on the river. The Warrensburg Woolen Company owns and holds for sale the property on the right bank, where it formerly had a woolen-mill which was burned. The old dam stood a short distance below the present one, but, the bank at one end being sandy, water worked around the dam and carried it out. The present structure is a rough affair, perhaps 100 feet in length, with a long wing extending down to the mills and forming one side of the race. The establishments are small, and comprise a planing- and saw-mill, a sash-, door-, and blind-factory, and a shoe-peg factory. They are located on the left bank, use a fall of 10 feet, and have water-wheels with an aggregate rating of about 135 horse-power. For two or three weeks every year the supply of water is insufficient to meet the needs of these concerns.

Estimate of power at the lower water-privilege in the village of Warrensburg.

Stage of river.	Rainfall on basin.(a) Spring.	Summer.	Autumn.	Winter.	Year.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 foot fall.	10 feet fall.	Effective horse-power utilized.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	9	12	11	8	40	535	80	9.09	90	135±
Low water, average year							100	11.36	110	
Available 10 months, average year							150	17.04	170	

a Roughly estimated; no data for accurate determination.

The third dam on the Schroon is near the center of Warrensburg village, and is a log structure about 100 feet long. There is considerable fall below the dam, and the head obtained ranges from 4½ feet at the dam to 9 feet below. On the right bank B. P. Burhaus & Son use power in a saw-mill and a large tannery; they also have a 4-run grist-mill on the opposite side of the river. There are also located on this privilege A. C. Emerson & Co.'s saw-mill, sawing from 2,000,000 to 2,500,000 feet of lumber yearly, and a small carding-shop.

For 6 or 8 miles above Warrensburg the river twists about among low and extensive flats, partly timbered, and probably a half to three-quarters of a mile wide. In 6 miles by direct course from the village the river is said to have an actual length, following the windings, of 18 miles. Throughout this distance it is sluggish, but is then succeeded above by short rapids, where about 7 feet of fall was formerly in use at Richards' saw-mill, part of the old log dam still remaining. The river is at that point from 50 to 75 feet wide in a low stage, and has a bed of gravel and bowlders. The river was not examined far above this locality. Quiet water succeeds the short rapids at Richards' mill-site, and some 2 miles beyond there are rapids again, known as Hunt's falls. The hills are then said to close in, and the valley to continue quite narrow until within a few miles of Schroon lake, at which distance there is a dam, with power in use at a tannery.

Drainage areas of Schroon river.

Locality.	Square miles.
Outlet of Schroon lake, above the stream from Pottersville	304
Horicon, below Brant Lake outlet	496
Warrensburg	535
Mouth of river	556

Table of utilized power on the Hudson river and tributaries.

[Based mainly upon returns by census enumerators in 1880.]

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	H. P.	H. P.	
Hudson river	Atlantic ocean	New York	Albany	Iron castings and finishings.	1	Ordinary fall, from 7 to 8 feet.	32	22	Privilege at state dam—Troy and Green Island.
Do	do	do	do	Saw	1		50		
Do	do	do	do	Window blinds and shades.	1		74		
Do	do	do	Rensselaer	Flouring and grist	2		290		
Do	do	do	do	Machinery	1		72		
Do	do	do	do	Paper	3		720+		
Do	do	do	do	Sashes, doors, and blinds	1		55		
Do	do	do	Saratoga	Paper	1	9	500	75	Property since purchased by the Hudson River Water Power & Paper Company, and mill not in operation in the fall of 1882.
Do	do	do	do	Flouring and grist	1	7–8	60		Stillwater.
Do	do	do	do	Paper	2		140	80	
Do	do	do	do	Hosiery	3		150	75	
Do	do	do	Washington	Saw	1	9	160(?)		Saratoga dam.
Do	do	do	do	Flouring and grist	1	10–11	50±		Fort Miller.
Do	do	do	do	Paper	1		200		
Do	do	do	do	Blast-furnace	1	8			Fort Edward.
Do	do	do	do	Flouring and grist	1		90		
Do	do	do	do	Machinery	1		40		
Do	do	do	do	Paper	1		90		
Do	do	do	do	Saw	2		600(?)		
Do	do	do	do	Stone and earthen ware	1		60		
Do	do	do	do	Machinery	1	55	40		Baker's Falls.
Do	do	do	do	Paper	3		1,807		
Do	do	do	do	Saw	1	7–9	900(?)		Upper privilege at Sandy Hill.
Do	do	do	Saratoga	do	1				
Do	do	do	Saratoga and Warren.	Flouring and grist	2	40	2,000–2,100		Glens Falls privilege.
Do	do	do	do	Lime	1				
Do	do	do	do	Marble-works	1				
Do	do	do	do	Paper	1				
Do	do	do	do	Planing	2				
Do	do	do	do	Saw	2				
Do	do	do	do	do	3	14	(a)		Feeder-dam.
Do	do	do	Saratoga	Paper and wood-pulp	1	20–30	1,450–1,500		Palmer falls.
Do	do	do	do	Wood-pulp	1	13	120		Hadley.
Croton river and tributaries.	Hudson river	do	Westchester	Flouring and grist	7	105	199		
Do	do	do	do	Iron castings and finishings.	1	11	10		
Do	do	do	do	Saw	8	71+	193		
Do	do	do	do	Spectacles and eye-glasses.	1	19	30	30	
Do	do	do	do	Wheelwrighting	1	7	17		
Do	do	do	do	Woolen	1	9	17		
Do	do	do	Putnam	Butter and cheese	1	8	75	580	
Do	do	do	do	Flouring and grist	9	130	164		
Do	do	do	do	Saw	3	34	85		
Do	do	do	Dutchess	Flouring and grist	1	28	20		
Do	do	Connecticut	Fairfield	Saw	1	8	15		
Murderer's creek and tributaries.	do	New York	Orange	Flouring and grist	10	197	314	40	
Do	do	do	do	Paper	2	54	424	185	
Do	do	do	do	Saw	1	12	10		
Do	do	do	do	Tannery	1	30	18		
Fishkill creek	do	do	Dutchess	Carpets	1	27	350	1,010	
Do	do	do	do	Flouring and grist	5	56	193		
Do	do	do	do	Furniture	1	4	25	25	
Do	do	do	do	Hats	2	58	400	375	
Do	do	do	do	Rubber and elastic goods	1	25	245		
Do	do	do	do	Straw goods	1	28	200	125	
Do	do	do	do	Woolen	1	22	400	300	
Tributaries	Fishkill creek	do	do	Flouring and grist	9	114	239	56	
Wappinger creek	Hudson river	do	do	Carriage and wagon materials.	1	11	65	40	

a No reliable returns; possibly as high as 1,500.

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Wappinger creek	Hudson river	New York	Dutchess	Coffins, burial-cases, and undertakers' goods.	1	9	6		
Do	do	do	do	Cotton	2	39	198		
Do	do	do	do	Flouring and grist	8	108	223		
Do	do	do	do	Paper	1	12	42	65	
Do	do	do	do	Saw	2	21	42	14	
Do	do	do	do	Wheelwrighting	1	10	10		
Do	do	do	do	Woolen	1	12	80	25	
Tributaries	Wappinger creek	do	do	Butter and cheese	1	16	8	10	
Do	do	do	do	Flouring and grist	9	199	398	50	
Do	do	do	do	Paper	1	24	24		
Do	do	do	do	Saw	4	43	57		
Do	do	do	do	Tobacco and cigars	1	12	6		
Do	do	do	do	Woolen	1	9	10		
Rondout creek and tributaries.	Hudson river	do	Ulster	Carpets	1	18	300		
Do	do	do	do	Carriage and wagon materials.	1	12	20		
Do	do	do	do	Children's carriages and sleds.	1	15	40		
Do	do	do	do	Cooperage	1	20	15	15	
Do	do	do	do	Cutlery and edge-tools	2	37	108		
Do	do	do	do	Excelsior	1	9	25		
Do	do	do	do	Flouring and grist	18	296	674		
Do	do	do	do	Furniture	1	7	15		
Do	do	do	do	Gunpowder	1	12	300		
Do	do	do	do	Lime	1	18	8	14	
Do	do	do	do	Lumber, planed	1	10	8		
Do	do	do	do	Paper	3	170	40		
Do	do	do	do	Sashes, doors, and blinds	1	12	25		
Do	do	do	do	Saw	26	370+	452		
Do	do	do	do	Tanneries	2	30	58	25	
Do	do	do	do	Wheelwrighting	1	30	6		
Do	do	do	do	Woolen	2	32	13		
Do	do	do	Sullivan	Flouring and grist	4	36+	100		
Do	do	do	do	Saw	4	53	62		
Do	do	do	Orange	Flouring and grist	21	316	532	45	
Do	do	do	do	Paper	2	40	100	200	
Do	do	do	do	Saw	12	120	249		
Do	do	do	do	Shoddy	1	13	40		
Do	do	do	do	Tanneries	2	15	14		
Do	do	do	do	Woolen	2	47	92	40	
Do	do	do	do	Worsted	1	9	90		
Do	do	New Jersey	Sussex	Agricultural implements	1	30	37		
Do	do	do	do	Flouring and grist	16	261+	470	10	
Do	do	do	do	Iron castings and finishings.	1	10	6	10	
Do	do	do	do	Saw	4	120	56		
Do	do	do	do	Tannery	1	8	8		
Do	do	do	do	Woolen	1		35		
Esopus creek	do	New York	Ulster	Carriage and wagon materials.	2	19	55		
Do	do	do	do	Flouring and grist	6	87	215	25	
Do	do	do	do	Furniture	1	8	15		
Do	do	do	do	Paints	2	20	95		
Do	do	do	do	Paper	1	31	450	320	
Do	do	do	do	Wood-pulp	1	8	80		
Do	do	do	do	Saw	16	201	570	20	
Tributaries	Esopus creek	do	do	Flouring and grist	7	109	309		
Do	do	do	do	Furniture	1	30	50		
Do	do	do	do	Paper	1	8	20	90	
Do	do	do	do	Saw	19	199+	433		
Do	do	do	do	Tannery	1	12	10	40	
Do	do	do	do	Wood turning and carving	1		20		
Do	do	do	Greene	Saw	3	48	55		
Jansen's kill and tributaries.	Hudson river	do	Columbia	Agricultural implements	1	20	4		
Do	do	do	do	Flouring and grist	4	70	94		

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Jansen's kill and tributaries.	Hudson river	New York	Columbia	Paper	3	76	250		
Do	do	do	do	Saw	3	29	23		
Do	do	do	Dutchess	Flouring and grist	4	46	84		
Catskill creek	do	do	Greene	Cotton	1		20		
Do	do	do	do	Hardware	2	22	35	12	
Do	do	do	do	Paper	1	30	50	15	
Do	do	do	do	Woolen	3	62	388	130	
Do	do	do	Albany	Flouring and grist	2	23	62		
Do	do	do	do	Saw	1	9	23		
Do	do	do	do	Tannery	1	13	28		
Do	do	do	Schoharie	Flouring and grist	2	36	40		
Do	do	do	do	Saw	1	9	35		
Tributaries	Catskill creek	do	Greene	Agricultural implements	1	14	10		
Do	do	do	do	Cooperage	2	24	18		
Do	do	do	do	Fire-arms	1	28	19		
Do	do	do	do	Flouring and grist	16	298	484	15	
Do	do	do	do	Furniture	2	26	16		
Do	do	do	do	Saw	15	196+	317	45	
Do	do	do	do	Tannery	1	12	10	25	
Do	do	do	do	Woolen	1	13	9		
Do	do	do	Albany	Flouring and grist	5	104	142		
Do	do	do	do	Paper	1	20	30	10	
Do	do	do	do	Saw	6	97	136		
Do	do	do	do	Woolen	1	9	8		
Do	do	do	Schoharie	Flouring and grist	1	16	10	12	
Do	do	do	Ulster	Saw	1	9	10		
Kinderhook creek	Hudson river	do	Columbia	Cotton	4	53+	680	265	
Do	do	do	do	Flouring and grist	2	19	133		
Do	do	do	do	Furniture	1	14	10		
Do	do	do	do	Paper	4	65	429		
Do	do	do	do	Woolen	1	10	40		
Do	do	do	Rensselaer	Flouring and grist	2	38	60		
Tributaries	Kinderhook creek	do	Columbia	Agricultural implements	3	26	16		
Do	do	do	do	Brooms and brushes	1		8		
Do	do	do	do	Cotton	3	160	358	378	
Do	do	do	do	Flouring and grist	25	524	790	40	
Do	do	do	do	Hosiery	3	23+	145	155	
Do	do	do	do	Machinery	3	50	120		
Do	do	do	do	Paper	16	291+	833	318	
Do	do	do	do	Pumps	1	20	6		
Do	do	do	do	Saw	15	274	314		
Do	do	do	do	Tannery	1	12	10		
Do	do	do	do	Upholstering materials	2	29	50		
Do	do	do	do	Woolen	1	24	75	40	
Do	do	do	Rensselaer	Blacksmithing	1	13	16		
Do	do	do	do	Flouring and grist	2	26	34		
Do	do	do	do	Paper	1	16	83		
Do	do	do	do	Saw	3	29	50		
Do	do	do	do	Wheelwrighting	1	16	10		
Do	do	do	do	Wooden handles	2	30	16		
Do	do	Massachusetts	Berkshire	Flouring and grist	1	12	9		
Do	do	do	do	Woolen	1	16	10		
Poesten kill and tributaries.	Hudson river	New York	Rensselaer	Agricultural implements	2	43	215		
Do	do	do	do	Cotton	1	28	80	220	
Do	do	do	do	Electroplating	2	41	22	30	
Do	do	do	do	Files	1	21	25		
Do	do	do	do	Flouring and grist	4	90	295		
Do	do	do	do	Hosiery	1	26	88		
Do	do	do	do	Iron castings	2	20	200	100	
Do	do	do	do	Lumber, planed	1	39	8	25	
Do	do	do	do	Machinery	1	25	70	15	
Do	do	do	do	Paper	2	67	210		Stream uncertain, but supposed to be the Poesten kill.
Do	do	do	do	Saddlery hardware	1	21	25		
Do	do	do	do	Saw	3	33	70		

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Poesten kill and tributaries.	Hudson river	New York	Rensselaer	Shirts	1	13	15	......	
Do	do	do	do	Steel car- and wagon-springs.	1	36	110	......	
Do	do	do	do	Wheelwrighting	1	13	15	......	
Do	do	do	do	Wire	2	50	175	......	
Do	do	do	do	Woolen	1	20	15	......	
Mohawk river	do	do	Saratoga	Flouring and grist	1		80	......	
Do	do	do	do	Hardware	2		75	......	King's ditch, Waterford. Total water-power utilized as here enumerated, 443 horse-power.
Do	do	do	do	Iron bolts, nuts, washers, and rivets.	1	13–14	20	......	
Do	do	do	do	Machinery	1		40	......	
Do	do	do	do	Paper	2		228	190	
Do	do	do	do	Hosiery	1	12	130	......	Himes and Vail.
Do	do	do	do	do	1	10	125	......	State dam, Waterford and Cohoes.
Do	do	do	Albany	Axes	1		......	......	
Do	do	do	do	Boxes, fancy and paper	1	Total fall developed above state dam, about 104 feet.	45	......	
Do	do	do	do	Carpentering	1		64	......	
Do	do	do	do	Cotton (print-cloths)	5		3,690	......	Harmony Mills.
Do	do	do	do	Cotton warps, batting, etc.	3–4		495	......	
Do	do	do	do	Cutlery and edge-tools	2		350	......	
Do	do	do	do	Furniture	2		50	......	
Do	do	do	do	Hosiery	16		1,415	......	Eighteen mills in fall of 1882. Cohoes. Total water-power utilized in 1880 as here enumerated, 6,556 horse-power. Increased by perhaps 300 horse-power up to the fall of 1882.
Do	do	do	do	Machinery	4		150	60	
Do	do	do	do	Paper	1		50	......	
Do	do	do	do	Printing and publishing	1		2	......	
Do	do	do	do	Sashes, doors, and blinds	1		40	......	
Do	do	do	do	Shirts	1		45	......	
Do	do	do	do	Wood-pulp	1		60	......	
Do	do	do	do	Wrought-iron pipe	1		100	......	
Do	do	do	Saratoga	Grist and saw	1	5–8	25–50	......	Lower aqueduct.
Do	do	do	Albany	Power supplied for pumping.	..	8	100	......	West Troy water-works.
Do	do	do	Herkimer	Agricultural implements	1	Total fall on 3 privileges, about 45 feet.	60	......	
Do	do	do	do	Axes	1		100	......	
Do	do	do	do	Carpentering	1		....	......	
Do	do	do	do	Condensed milk	1		....	......	
Do	do	do	do	Cotton	1		75	......	
Do	do	do	do	Electrical apparatus	1		120	......	
Do	do	do	do	Fertilizers	1		50	......	
Do	do	do	do	Flouring and grist	1		150	......	
Do	do	do	do	Hardware	1		110	......	Little Falls. Total water-power in use, as here enumerated, 1,307 horse-power.
Do	do	do	do	Knit underwear	2		110	50+	
Do	do	do	do	Lasts	1		7	......	
Do	do	do	do	Lumber, planed	2		105	......	
Do	do	do	do	Machinery	1		50	......	
Do	do	do	do	Paper	2		200	......	
Do	do	do	do	Saw	1		20	......	
Do	do	do	do	Starch	1		50	50	
Do	do	do	do	Wool extract	1		20	......	
Do	do	do	do	Woolen	1		80	60	
Do	do	do	Oneida	Flouring and grist	6	59	141	......	
Do	do	do	do	Pumping-works	1	10–12	200	......	Rome.
Do	do	do	do	Sashes, doors, and blinds	1	8	20	......	
Do	do	do	do	Saw	3	33	50	......	
Do	do	do	Lewis	do	2	26	45	......	
Schoharie creek and tributaries.	Mohawk river	do	Montgomery	Grist and saw	1	7	50±	......	Auriesville, main stream.
Do	do	do	do	Brooms and brushes	1		38	......	
Do	do	do	do	Flouring and grist	1	12	75	......	Mill Point, main stream.
Do	do	do	do	Saw	1		39	......	
Do	do	do	do	Flouring and grist	1		50	......	
Do	do	do	do	Saw	1	14	30	......	Charleston, main stream.
Do	do	do	do	Wheelwrighting	1		15	......	
Do	do	do	do	do	1	8	10	......	Location of privileges uncertain.
Do	do	do	do	Woolen	1	12	40	......	

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Schoharie creek and tributaries.	Mohawk river	New York	Schoharie	Agricultural implements	5	64	65	....	
Do	do	do	do	Carpentering	1	12	12	....	
Do	do	do	do	Churns	1	12	20	....	
Do	do	do	do	Cooperage	1	7	14	....	
Do	do	do	do	Flouring and grist	26	484	960	....	
Do	do	do	do	Furniture	1	12	12	....	
Do	do	do	do	Machinery	1	16	15	6	
Do	do	do	do	Paper	1	17	50	40	
Do	do	do	do	Saw	45	577	1,202	20	
Do	do	do	do	Tanneries	2	25	30	....	
Do	do	do	do	Wheelwrighting	2	20	18	....	
Do	do	do	do	Woolen	2	45	21	....	
Do	do	do	Greene	Cotton	1	30	75	....	
Do	do	do	do	Flouring and grist	4	85	143	....	
Do	do	do	do	Furniture	1	11	30	15	
Do	do	do	do	Saw	7	96	178	....	
Do	do	do	do	Tannery	1	8	5	....	
Do	do	do	do	Wood turning and carving	1	12	5	....	
Do	do	do	Albany	Flouring and grist	4	99	140	....	
Do	do	do	do	Saw	6	92	138	....	
Do	do	do	do	Tannery	1	5½	4	....	
Cayadutta creek	do	do	Montgomery	Flouring and grist	2	40½	170	....	
Do	do	do	do	Saw	1	11	20	....	
Do	do	do	Fulton	Flouring and grist	1	16	40	25	
Do	do	do	do	Gloves and mittens	2	38	90	4	
Do	do	do	do	Lumber, planed	1	6	8	....	
Do	do	do	do	Skins, dressed	16	273	454	....	
Tributaries	Cayadutta creek	do	do	Flouring and grist	1	15	40	....	
Do	do	do	do	Skins, dressed	1	14	30	....	
East Canada creek	Mohawk river	do	Herkimer	Cheese-boxes	1				
Do	do	do	do	Cider	1				
Do	do	do	do	Flouring and grist	1	10	60±	....	Ingham's Mills.
Do	do	do	do	Saw	1				
Do	do	do	do	Felt	1				
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Piano and organ sounding-boards.	1	20	290	170±	Dolgeville.
Do	do	do	do	Saw	1				
Do	do	do	Fulton	do	3	32	90		
Tributaries	East Canada creek	do	do	Cooperage	2	22	55	....	
Do	do	do	do	Saw	16	216	528	60	
Do	do	do	do	Tannery	1	23	70	40	
Do	do	do	Herkimer	Flouring and grist	2	43	135	....	
Do	do	do	do	Furniture	1	9	16	....	
Do	do	do	do	Saw	6	88	177	....	
Do	do	do	do	Shoe-pegs	1	10	20	....	
Do	do	do	do	Tannery	1	8	10	....	
Do	do	do	do	Toys and games	1	11	8	....	
West Canada creek	Mohawk river	do	do	Flouring and grist	1		50	....	
Do	do	do	do	Furniture	1		....	....	
Do	do	do	do	Hosiery	1		60	75	
Do	do	do	do	Paper	1	14, 21	150	....	Herkimer.
Do	do	do	do	Plaster	1		....	....	
Do	do	do	do	Sashes, doors, and blinds	2		25+	....	
Do	do	do	do	Saw	1		40	....	
Do	do	do	do	Flouring and grist	2		130	....	
Do	do	do	do	Saw	2		23	....	
Do	do	do	do	Tannery	1	20±	6	....	Middleville and Newport.
Do	do	do	do	Wheelwrighting	1		8	....	
Do	do	do	do	Saw	2	22	55	....	
Do	do	do	Oneida	Flouring and grist	1	14	45±	....	Trenton Falls.
Do	do	do	do	do	1	18	90	....	Prospect.
Do	do	do	do	Tannery	1		26	....	
Tributaries	West Canada creek	do	do	Butter and cheese	1	6	4	....	
Do	do	do	do	Flouring and grist	1	30	60	....	
Do	do	do	do	Saw	3	41	42	....	
Do	do	do	do	Wheelwrighting	1	30	8	....	

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	West Canada creek	New York	Herkimer	Flouring and grist	6	127	101		
Do	do	do	do	Furniture	1	9	6		
Do	do	do	do	Machinery	1	14	8		
Do	do	do	do	Sashes, doors, and blinds	2	25	25		
Do	do	do	do	Saw	23	331	485		
Do	do	do	do	Saws	1	13	10		
Do	do	do	do	Tanneries	2	20	43	35	
Do	do	do	do	Wheelwrighting	1	6	16		
Do	do	do	do	Wood turning and carving	1	23	12		
Do	do	do	do	Wooden handles	1	16	20		
Do	do	do	do	Woodenware	2	23	20	8	
Do	do	do	do	Woolen	1	12	6		
Sauquoit creek	Mohawk river	do	Oneida	Agricultural implements	2	45	200		
Do	do	do	do	Cotton	4	101	1,160	1,170	
Do	do	do	do	Cotton-batting	1	4	6	6	
Do	do	do	do	Flouring and grist	3	40	155		
Do	do	do	do	Hosiery	1	10	30	50	
Do	do	do	do	Lumber, planed	1	15	35		
Do	do	do	do	Saw	3	39	140		
Do	do	do	do	Silk	1	18	50		
Do	do	do	do	Woolen	2	56	178	200	
Tributaries	Sauquoit creek	do	do	Carriages and wagons	1	7½	8		
Do	do	do	do	Furniture	1	23	12		
Do	do	do	do	Machinery	1	24	10		
Do	do	do	do	Maps and atlases	1	10	4		
Do	do	do	do	Wheelwrighting	1	10	4		
Do	do	do	do	Wood turning and carving	2	36	18		
Oriskany creek and tributaries.	Mohawk river	do	do	Carriages and wagons	1	20	15	12	
Do	do	do	do	Cotton	2	41	290		
Do	do	do	do	Cotton-batting	1	10	50		
Do	do	do	do	Felt	1	14	100	100	
Do	do	do	do	Flouring and grist	8	117	539		
Do	do	do	do	Paints	1	20	20		
Do	do	do	do	Saw	3	35	90		
Do	do	do	do	Wheelwrighting	1	9	12		
Do	do	do	do	Woolen	2	28	45		
Do	do	do	Madison	Flouring and grist	2	26	70		
Do	do	do	do	Saw	3	33	70		
Minor tributaries	do	do	Albany	Flouring and grist	1	18	20		
Do	do	do	do	Saw	1	18	20		
Do	do	do	Schenectady	Flouring and grist	4	116	160		
Do	do	do	do	Hosiery	1	40	50	80	
Do	do	do	Saratoga	Flouring and grist	5	76	375		
Do	do	do	do	Saw	7	80	176		
Do	do	do	Montgomery	Agricultural implements	1	42	50		
Do	do	do	do	Bags (not paper)	1	27	25	20	
Do	do	do	do	Bee-hives	1	12	12	20	
Do	do	do	do	Carpets	1	30	240	500	
Do	do	do	do	Carriages and wagons	1	12	17		
Do	do	do	do	Carriage and wagon materials.	2	63	49		
Do	do	do	do	Car- and carriage-springs	1	20	50	50	
Do	do	do	do	Cooperage	2	18	30		
Do	do	do	do	Cotton	1	12	30	60	
Do	do	do	do	Fertilizers	1	17	35		
Do	do	do	do	Flouring and grist	11	204	349	15	
Do	do	do	do	Hosiery	8	160+	525	605	
Do	do	do	do	Linseed-oil	1	36	150		
Do	do	do	do	Machinery	1	16	35	40	
Do	do	do	do	Maps and atlases	1	27	25	20	
Do	do	do	do	Paper	3	80	272	195	
Do	do	do	do	Pumps	1	18	15		
Do	do	do	do	Saw	11	183	341	25	
Do	do	do	do	Shoddy	1	31	92		
Do	do	do	do	Skins, dressed	1	18	12		
Do	do	do	do	Woolen	2	36	48	20	
Do	do	do	Fulton	Flouring and grist	2	38	70		

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Minor tributaries	Mohawk river	New York	Fulton	Furniture	1	10	10	....	
Do	do	do	do	Gloves and mittens	1	10	10	....	
Do	do	do	do	Paper	7	121	245	50	
Do	do	do	do	Saw	11	172	337	....	
Do	do	do	do	Shoe-pegs	1	10	10	....	
Do	do	do	do	Skins, dressed	2	14½	26	....	
Do	do	do	do	Tannery	1	15	16	....	
Do	do	do	do	Wheelwrighting	1	15	6	....	
Do	do	do	do	Wooden handles	1	17	15	....	
Do	do	do	do	Woolen	1	12	50	....	
Do	do	do	Herkimer	Flax, dressed	1	10	12	....	
Do	do	do	do	Flouring and grist	6	116	205	....	
Do	do	do	do	Furniture	1	28	28	....	
Do	do	do	do	Matches	1	22	45	50	
Do	do	do	do	Saw	9	187	261	....	
Do	do	do	do	Wheelbarrows	1	18	60	....	
Do	do	do	do	Wheelwrighting	1	8	10	....	
Do	do	do	Oneida	Flouring and grist	5	60+	138	....	
Do	do	do	do	Hosiery	1	16	30	30	
Do	do	do	do	Machinery	1	10	8	....	
Do	do	do	do	Saw	17	189+	326	....	
Do	do	do	do	Wheelbarrows	1	10	6	....	
Do	do	do	do	Wooden packing-boxes	3	27	29	....	
Do	do	do	Otsego	Furniture	1	10	8	....	
Hoosac river	Hudson river	do	Rensselaer	Woolen	1	30–34	170	....	Schaghticoke.
Do	do	do	do	Flouring and grist	1		45±	....	
Do	do	do	do	Cordage and twine	3	8, 7½	310	100	Cable flax-mills.
Do	do	do	do	Paper	1		100±	....	
Do	do	do	do	Gunpowder	1	8, 12	208	12	Schaghticoke.
Do	do	do	do	Linen twines, yarns, etc	1	15–16	540	10	Valley Falls.
Do	do	do	do	Knit-goods	1				
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Paper	1				
Do	do	do	do	Agricultural implements, axes, etc.	1	8	150	....	Johnsonville.
Do	do	do	do	Flouring and grist	2		45	....	
Do	do	do	do	Agricultural implements	1	19	300	160	Hoosac Falls.
Do	do	Vermont	Bennington	Cotton	1	17	330	250	
Do	do	do	do	Hosiery, etc	1	9	50–60	....	
Do	do	Massachusetts	Berkshire	Cotton	19	330	3,048	2,230	Including 5 privileges for the Renfrew Manufacturing Company, and 4 for the Freeman Print Works.
Do	do	do	do	Flouring and grist	2	24	100	....	
Do	do	do	do	Marble-dust	1	80	90	60	
Do	do	do	do	Paper	2	12	244	220	
Do	do	do	do	Tannery	1	5½	17	....	
Do	do	do	do	Woolen	5	86	619	405	
Tributaries	Hoosac river	do	do	Cotton	2	28	52	75	
Do	do	do	do	Flouring and grist	1	30	30	....	
Do	do	do	do	Kaolin and ground earths	1	15	15	....	
Do	do	do	do	Machinery	1	26	15	10	
Do	do	do	do	Tannery	1	12	15	....	
Do	do	Vermont	Bennington	Carriages and wagons	1	8	8	....	
Do	do	do	do	Cotton	2	43	180	100	
Do	do	do	do	Drugs and chemicals	1	15	5	....	
Do	do	do	do	Flouring and grist	5	69	92	....	
Do	do	do	do	Glass, cut, stained, and ornamented.	1	150	8	8	
Do	do	do	do	Hardware	1	....	15	....	
Do	do	do	do	Hosiery	5	97½	190	220	
Do	do	do	do	Kaolin and ground earths	4	115	97	....	
Do	do	do	do	Machinery	3	70	89	....	
Do	do	do	do	Paper	2	31	150	12	
Do	do	do	do	Photographing	1	120	33	....	
Do	do	do	do	Saw	13	212	855	48	
Do	do	do	do	Stone- and earthen-ware	1	8	12	....	
Do	do	do	do	Tannery	1	7	16	....	
Do	do	do	do	Wooden packing-boxes	1	12	20	....	

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Hoosac river	Vermont	Bennington	Wooden ware	1	15	20	......	
Do	do	do	do	Woolen	1	16, 32	225	250	
Do	do	New York	Rensselaer	Cooperage	1	9	45	......	
Do	do	do	do	Flouring and grist	8	167	299	10	
Do	do	do	do	Furniture	1	12	10	......	
Do	do	do	do	Iron castings	1	10	4	......	
Do	do	do	do	Paper	2	38	537	......	
Do	do	do	do	Saw	10	204	271	40	
Do	do	do	do	Wooden packing boxes	1	20	5	10	
Do	do	do	Washington	Agricultural implements	1	16	22	......	
Do	do	do	do	Cordage and twine	2	18	120	......	
Do	do	do	do	Flax, dressed	1	10	12	......	
Do	do	do	do	Flouring and grist	4	82	198	......	
Do	do	do	do	Saw	4	73	127	......	
Fish creek	Hudson river	do	Saratoga	Flouring and grist	1	14–20	370±	......	Lower privilege.
Do	do	do	do	Machinery	1				
Do	do	do	do	Paper	1				
Do	do	do	do	Sashes, doors, and blinds	1				
Do	do	do	do	Cotton	2	64	960	450	Saratoga Victory Manufacturing Company. About 760 horse-power actually in use.
Do	do	do	do	Grist and saw	1	14	115	......	
Kayaderosseras creek and tributaries.	Fish creek	do	do	Agricultural implements	3	49	391	137	
Do	do	do	do	Flouring and grist	11	171	370	......	
Do	do	do	do	Machinery	1	11	37	......	
Do	do	do	do	Paper	10	157	1,012	790	
Do	do	do	do	Paper bags	1	20	13	7	
Do	do	do	do	Paper collars and cuffs	1	18	77	25	
Do	do	do	do	Sashes, doors, and blinds	1	11	37	......	
Do	do	do	do	Saw	9	110+	243	25	
Do	do	do	do	Tanneries	3	31+	65	75	
Do	do	do	do	Wheelwrighting	1	11	7	......	
Other tributaries	do	do	do	Saw	1	10	26	......	
Batten kill	Hudson river	do	Washington	Plaster	1	10	......	......	Clark's Mills.
Do	do	do	do	Sashes, doors, and blinds	1				
Do	do	do	do	Saw	1				
Do	do	do	do	Blankets	1	47	565±	......	Middle Falls.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Saw and plaster	1				
Do	do	do	do	Wood-pulp and leather-board.	1				
Do	do	do	do	Linen threads, yarns, and twines.	1	11½	130	......	Greenwich.
Do	do	do	do	Cotton-batting	1	10-12	250±	......	
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Flax, dressed	1				
Do	do	do	do	Shirts	1				
Do	do	do	do	Saw	1				
Do	do	do	do	Knit underwear	1	7½	70	......	
Do	do	do	do	Paper	1		60	......	
Do	do	do	do	Flouring and grist	1	9	175±	......	Battenville.
Do	do	do	do	Paper	1				
Do	do	do	do	Saw	1				
Do	do	do	do	Blankets	1	7½	180±	......	East Greenwich.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Sashes and blinds	1				
Do	do	do	do	Saw	1				
Do	do	do	do	Marble sawed	1	7	24	......	Baxterville.
Do	do	do	do	Iron foundery	1	7	120±	......	Shushan.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Saw	1				
Do	do	do	do	Shirts	1				
Do	do	do	do	Woolen	1				
Do	do	do	do	do	1	6	30	......	
Do	do	Vermont	Bennington	Brooms and brushes	1	7	35	......	
Do	do	do	do	Marble- and stone-works	2	40	90	40	
Do	do	do	do	Saw	3	22+	105	......	

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Tributaries	Batten kill	Vermont	Bennington	Brooms and brushes	1	19	55	....	
Do	...do	...do	...do	Cooperage	1	16	25	....	
Do	...do	...do	...do	Flouring and grist	5	87	100	....	
Do	...do	...do	...do	Furniture	1	13	40	....	
Do	...do	...do	...do	Iron castings	1	13	12	....	
Do	...do	...do	...do	Leather, tanned and curried.	1	12	15	30	
Do	...do	...do	...do	Lumber, planed	1	9	18	....	
Do	...do	...do	...do	Machinery	1	4	4	....	
Do	...do	...do	...do	Saw	18	400+	596	60	
Do	...do	...do	...do	Wooden handles	3	42	42	....	
Do	...do	...do	...do	Wooden ware	3	55	44	....	
Do	...do	New York	Washington	Agricultural implements	1	20	12	....	
Do	...do	...do	...do	Flax, dressed	1	8	15	....	
Do	...do	...do	...do	Fouring and grist	3	38	155	....	
Do	...do	...do	...do	Saw	3	31	95	35	
Do	...do	...do	...do	Starch	1	14	12	....	
Sacondaga river	Hudson river	...do	Saratoga	Wood-pulp	2	27	650±	....	Hadley.
Do	...do	...do	...do	Wooden ware	1	12	....	....	Do.
Do	...do	...do	...do	Tannery	1				
Do	...do	...do	...do	Flouring and grist	1	20	30	....	Providence.
Do	...do	...do	Hamilton	Saw	1	10	20	....	Wells.
Do	...do	...do	...do	Tanneries	2	8	58	50	Hope.
Tributaries	Sacondaga river	...do	...do	Lumber, planed	1	21	40	....	
Do	...do	...do	...do	Saw	6	67	169	....	
Do	...do	...do	...do	Tanneries	2	21	70	102	
Do	...do	...do	Fulton	Agricultural implements	1	8	10	....	
Do	...do	...do	...do	Blacksmithing	1	11	10	....	
Do	...do	...do	...do	Cooperage	2	26	40	....	
Do	...do	...do	...do	Flouring and grist	6	82	274	45	
Do	...do	...do	...do	Iron castings and finishings.	1	6	6	....	
Do	...do	...do	...do	Lumber, planed	1	9	20	....	
Do	...do	...do	...do	Paper	5	63	105	70	
Do	...do	...do	...do	Saw	17	222	477	50	
Do	...do	...do	...do	Shoe-pegs	1	10	10	....	
Do	...do	...do	...do	Skins, dressed	2	22	29	16	
Do	...do	...do	...do	Tanneries	3	17+	36	35	
Do	...do	...do	...do	Wooden ware	1	11	18	15	
Do	...do	...do	...do	Woolen	1	20	14	20	
Do	...do	...do	Saratoga	Agricultural implements	2	19	34	47	
Do	...do	...do	...do	Flouring and grist	4	69	190	....	
Do	...do	...do	...do	Furniture	2	28	23	....	
Do	...do	...do	...do	Machinery	1	15	15	....	
Do	...do	...do	...do	Saw	14	238	363	20	
Do	...do	...do	...do	Tanneries	2	33	27	....	
Do	...do	...do	...do	Wheelwrighting	1	18	20	....	
Do	...do	...do	...do	Wooden ware	2	34	50	....	
Schroon river and tributaries.	Hudson river	...do	Warren	Wool carding	1	....	18	....	
Do	...do	...do	...do	Flouring and grist	3	30	185	....	
Do	...do	...do	...do	Planing	1	....	....	....	
Do	...do	...do	...do	Sashes, doors, and blinds	1	....	....	....	
Do	...do	...do	...do	Saw	2	....	....	....	
Do	...do	...do	...do	Shoe-pegs	1	....	....	....	
Do	...do	...do	...do	Tannery	1	....	....	....	
Do	...do	...do	...do	Wood-pulp	1	12	150	....	
Do	...do	...do	...do	Woolen	2	16	30	....	
Do	...do	...do	Essex	Flouring and grist	2	36	60	....	
Do	...do	...do	...do	Saw	12	150	534	....	
Do	...do	...do	...do	Tannery	1	12	60	....	
All other tributaries.	...do	...do	Westchester	Carpets	1	12	40	760	
Do	...do	...do	...do	Cutlery and edge-tools	1	26	40	50	
Do	...do	...do	...do	Fertilizers	1	35	41	22	
Do	...do	...do	...do	Files	1	17	22	40	
Do	...do	...do	...do	Flouring and grist	8	126	352	95	
Do	...do	...do	...do	Sashes, doors, and blinds	1	13	8	10	

Table of utilized power on the Hudson river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
All other tributaries.	Hudson river	New York	Westchester	Silk	3	27+	97	165	
Do	do	do	do	Tannery	1	18	10	20	
Do	do	do	do	Wheelwrighting	1	23	6		
Do	do	do	do	Wire-works	1	25	44	185	
Do	do	do	Rockland	Flouring and grist	2	34	40		
Do	do	do	Orange	do	6	112	127		
Do	do	do	do	Machinery	2	20	24		
Do	do	do	do	Marble- and stone-works	1		6		
Do	do	do	do	Paper	2	35	215	195	
Do	do	do	do	Saw	2	25	24		
Do	do	do	do	Tanneries	2	30½	80		
Do	do	do	do	Woolen	5	78	311	300	
Do	do	do	Putnam	Flouring and grist	2	35	50		
Do	do	do	do	Paper	2	48	95	180	
Do	do	do	Ulster	Baskets, rattan- and willow-ware.	1	33	12	50	
Do	do	do	do	Carriage and wagon materials.	1	14	18		
Do	do	do	do	Cutlery and edge-tools	2	21	66	31	
Do	do	do	do	Dye woods, dye-stuffs, and extracts.	1	24	25		
Do	do	do	do	Excelsior	1	12	50	120	
Do	do	do	do	Flouring and grist	12	232	295		
Do	do	do	do	Paints	1	30	40		
Do	do	do	do	Saw	6	91+	117		
Do	do	do	do	Wheelbarrows	1	18	20	25	
Do	do	do	do	Woolen	2	61	44		
Do	do	do	Dutchess	Carpets	1	18	50	80	
Do	do	do	do	Cutlery and edge-tools	1	20	26		
Do	do	do	do	Dye woods, dye-stuffs, and extracts.	1	40	270	380	
Do	do	do	do	Flouring and grist	5	95	178	50	
Do	do	do	do	Hats	1	22	200	150	
Do	do	do	do	Saw	4	49½	72		
Do	do	do	do	Wood turning and carving	1	50	20	25	
Do	do	do	do	Woolen	1	12	26		
Do	do	do	Greene	Flouring and grist	4	110+	85	80	
Do	do	do	do	Paper	1	23	30		
Do	do	do	do	Saw	6	79+	103	35	
Do	do	do	do	Wooden ware	1	18	15		
Do	do	do	Albany	Flouring and grist	6	127	210		
Do	do	do	do	Hosiery	1	14	41		
Do	do	do	do	Paper	3	58	188	120	
Do	do	do	do	Saw	7	136	162		
Do	do	do	Rensselaer	Agricultural implements	2	44	36	10	
Do	do	do	do	Cordage and twine	2	25	35		
Do	do	do	do	Cotton	1	28	78		
Do	do	do	do	Drugs and chemicals	1	50	30		
Do	do	do	do	Flouring and grist	9	202	394		
Do	do	do	do	Hosiery	4	79	205		
Do	do	do	do	Paints	2	33	128		
Do	do	do	do	Paper	2	114½	175	150	
Do	do	do	do	Saw	7	120	113		
Do	do	do	do	Woolen	2	25	18		
Do	do	do	Saratoga	Cordage and twine	1	22	14		
Do	do	do	do	Fertilizers	2	30	85		
Do	do	do	do	Flouring and grist	11	179	386		
Do	do	do	do	Saw	6	74	142		
Do	do	do	do	Sashes, doors, and blinds	2	12	47		
Do	do	do	do	Woolen	1	12	16		
Do	do	do	Washington	Fertilizers	1		30		
Do	do	do	do	Flax, dressed	2	48	18		
Do	do	do	do	Flouring and grist	3	35½	108		
Do	do	do	do	Saw	3	61	100		
Do	do	do	do	Vinegar	2	23½	46		
Do	do	do	Warren	Flouring and grist	4	47	180		
Do	do	do	Essex	Saw	2	22	80		

Summary of utilized power on the

	Stream.	COTTON-MILLS. Number of mills.	COTTON-MILLS. Water-power utilized.	COTTON-MILLS. Auxiliary steam-power.	WOOLEN-MILLS. (*a*) Number of mills.	WOOLEN-MILLS. (*a*) Water-power utilized.	WOOLEN-MILLS. (*a*) Auxiliary steam-power.	HOSIERY- AND KNIT-UNDERWEAR MILLS. Number of mills.	HOSIERY- AND KNIT-UNDERWEAR MILLS. Water-power utilized.	HOSIERY- AND KNIT-UNDERWEAR MILLS. Auxiliary steam-power.	PAPER-MILLS. Number of mills.	PAPER-MILLS. Water-power utilized.	PAPER-MILLS. Auxiliary steam-power.	FLOURING- AND GRIST-MILLS. Number of mills.	FLOURING- AND GRIST-MILLS. Water-power utilized.	FLOURING- AND GRIST-MILLS. Auxiliary steam-power.
			H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
1	Hudson river							3	150	75	13	5,057	155	7	820	
2	Croton river and tributaries				1	17								17	382	
3	Murderer's creek and tributaries										2	424	185	10	314	40
4	Fishkill creek and tributaries				2	750	1,310							14	432	50
5	Wappinger creek and tributaries	2	198		2	90	25				2	66	65	17	621	50
6	Rondout creek and tributaries				7	530	40				5	240	240	59	1,776	55
7	Esopus creek and tributaries										2	470	410	13	524	25
8	Jansen's kill and tributaries										3	250		8	178	
9	Catskill creek and tributaries	1	20		5	405	130				2	80	25	26	738	27
10	Kinderhook creek and tributaries	7	1,038	643	3	125	40	3	145	155	21	1,345	318	32	1,026	40
11	Poesten kill and tributaries	1	80	220	1	15		1	88		2	210		4	295	
12	Mohawk river and tributaries	15	5,871	1,236	13	708	780	32	2,475	890	17	1,195	475	113	4,821	40
13	Hoosac river and tributaries	25	3,690	2,655	7	1,014	715	6	240	220	8	1,151	232	24	849	10
14	Fish creek and tributaries	2	960	450							13	1,324	822	13	595	
15	Batten kill and tributaries	1	10		4	112		1	70		2	135		13	673	
16	Sacondaga river and tributaries				1	14	20				5	105	70	11	494	45
17	Schroon river and tributaries				2	30								5	245	
18	All other tributaries of the Hudson river	1	78		13	505	1,140	5	246		10	698	645	72	2,405	175
	Total, Hudson river and all tributaries	55	11,945	5,204	61	4,315	4,200	51	3,414	1,340	107	12,750	3,642	458	17,189	557

a Including also carpet factories, of which there are several on the streams mentioned.

b Comprising iron-furnaces, blacksmithing and electro-plating shops, and works for the manufacture of agricultural implements, axes, cutlery and sundry saws, steel car- and wagon springs, wire, and wrought-iron pipe.

c Comprising carpentering, cooperage, wheelwrighting, and wood-turning and carving shops; and establishments for the manufacture of carriages and wagons, organ sounding-boards; sashes, doors, and blinds; shoe-pegs, wheelbarrows, wooden packing-boxes, wooden handles, and wooden ware.

d Comprising works for dressing flax; cutting, staining, and ornamenting glass; working in marble and stone; printing and publishing; dressing skins; and boxes, brooms and brushes, butter and cheese, cider, condensed milk, drugs and chemicals; dye-woods, dye-stuffs, and extracts; felt, fertilizers, gloves and mittens, goods, shirts, shoddy, silk, spectacles and eye-glasses, starch, stone- and earthen-ware, straw goods, tobacco and cigars, toys and games, upholstering materials, vinegar,

Hudson river and tributaries.

Saw-mills.			Metal-working establishments. (*b*)			Wood-working establishments. (*c*)			Tanneries.			Sundry other establishments. (*d*)			Total.			
Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	
	H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*	
11	4,750	....	5	184	22	4	219	....	....	....	....	4	265	....	47	11,445	252	1
12	203	....	1	10	....	1	17	....	....	....	....	2	105	610	34	825	610	2
1	10	....	....	....	....	....	....	....	1	18	....	....	....	....	14	766	225	3
....	....	....	....	....	....	1	25	25	....	....	....	4	845	500	21	2,052	1,885	4
6	99	14	....	....	....	3	81	40	....	....	....	2	14	10	34	1,169	204	5
46	819	....	4	151	10	8	154	15	5	80	25	3	348	14	137	4,098	399	6
38	1,058	20	....	....	....	5	140	....	1	10	40	3	175	....	62	2,377	495	7
3	23	....	1	4	....	....	....	....	....	....	....	....	....	....	15	455	....	8
24	521	45	4	64	12	4	34	....	2	38	25	....	....	....	68	1,900	264	9
18	364	....	8	158	....	4	36	....	1	10	....	3	58	....	100	4,305	1,196	10
3	70	....	12	842	145	2	23	25	....	....	....	1	15	....	27	1,638	390	11
190	5,013	105	32	1,647	156	65	1,163	105	11	210	75	50	1,884	194	538	24,987	4,056	12
27	753	88	9	505	170	6	108	10	3	48	....	18	1,210	180	133	9,658	4,280	13
10	269	25	5	455	137	3	54	....	3	65	75	....	....	....	49	3,722	1,509	14
30	1,021	95	4	73	....	11	204	....	1	15	30	14	901	40	81	3,214	165	15
38	1,029	70	6	75	47	12	221	15	10	191	187	4	679	10	87	2,808	470	16
14	534	....	....	....	....	3	....	....	2	60	....	2	168	....	28	1,037	....	17
48	913	35	10	258	316	9	184	180	3	90	20	23	1,077	767	189	6,454	3,278	18
514	17,539	497	101	4,516	1,015	141	2,663	415	43	835	477	133	7,744	2,331	1,664	82,910	19,678	

edge-tools, electrical apparatus, files, fire-arms; iron bolts, nuts, washers, and rivets; iron castings and finishings, saddlery and general hardware, machinery. pumps,

carriage and wagon materials, children's carriages and sleds, cheese-boxes, churns; coffins, burial-cases and undertakers' goods, excelsior, furniture, piano and

water-supply pumping; also photographing and wool-carding shops, and establishments for the manufacture of bags, baskets, rattan- and willow-ware, fancy and paper
gunpowder, hats, kaolin and ground earths, lasts, lime, linseed-oil, leather-board; linen threads, yarns, and twines: maps and atlases, paints, plaster, rubber and elastic
wood-pulp, and wool extract.

REPORT

ON THE

WATER-POWER OF LAKE GEORGE OUTLET.

FIG. 9. Map of the Lake George basin.

LAKE GEORGE OUTLET.

The beautiful sheet of water known as lake George lies in eastern New York state, opposite and a little to the west of the head of lake Champlain. It is 230 feet higher than the latter, into which its waters discharge from the northern extremity through Ticonderoga creek, $2\frac{1}{2}$ miles long. The length of the lake is about 32 miles; its width varies in general from 1 to 2 miles, but reaches $2\frac{1}{2}$ miles at a point near the head. The surface flowed amounts to 44 square miles, including the islands, which are numerous but small. The area tributary to the lake and its outlet is 238 square miles at the upper falls, and 262 square miles at the entrance into lake Champlain.

Lake George is bordered by high hills, or mountains, whose rocky slopes often rise precipitously from its shores. At its foot, where the width contracts, there are level meadows. Below the lake proper is a narrow arm reaching about a mile northward to the upper falls, and nowhere more than a few hundred feet across. The ranges of mountains which inclose the lake are there perhaps a mile apart, with rolling or moderately hilly land intervening. The range on the west runs off to the northward, and remains of quite uniform height except as it is now and then cut through transversely by valleys. The hills on the east side of the lower end of the lake subside somewhat, and striking to the eastward come to an abrupt end on the shore of lake Champlain. The latter is here about 1,400 feet wide, and on the opposite side the range is continued, beginning at mount Independence as suddenly as it had previously dropped off on the west shore at mount Defiance. The narrow arm of the lake terminates at the upper dam on the outlet, where the storage is controlled, and from there Ticonderoga creek runs down through a comparatively open valley, practically its entire descent being accomplished in the first mile. The fall is in two or three principal pitches, and is almost wholly over hard granitic and quartzose rock.

The lake is deep, and its sides dip steeply beneath the water. A depth of 100 feet will often be found within 30 feet of the shore; and within a few miles of the outlet, where the depth is greatest, it is said that soundings of 400 feet have failed to reach bottom. The water in the main body of the lake is wonderfully clear, and objects can plainly be seen 40 feet beneath the surface. In the narrow arm at the foot of the lake, however, there is a clayey bed which becomes stirred up and gives the water there and in the outlet a milky hue. A number of small streams, none more than 6 or 8 miles long, flow into the lake, but it is thought to receive a large portion of its water from hidden springs in the bed.

A short distance above the upper dam water is taken out for the village of Ticonderoga. About 1,500 people are supplied, under a head of 200 feet, by means of an 8-inch main having an estimated capacity of 470,000 gallons per twenty-four hours. The project has recently been broached of furnishing the various cities along the Hudson valley, down to and including New York, with water from this lake, though it is not probable that any advanced steps have been taken in the enterprise. The question is one of much importance to the inhabitants of the village of Ticonderoga, for the carrying out of the design would curtail their principal resource. Even supposing the plan practicable, its execution would probably meet with determined opposition.

The outlet, Ticonderoga creek, after passing for a mile or so down through the village, becomes slack-water on to lake Champlain. In colonial times freight was brought up in vessels to the lower falls, transferred to the lake, and shipped to its head, on the way to fort Edward. Lake George thus served as an important highway of traffic, and the reason is seen why the entrance was so strongly defended by forts. Previously to 1837 navigation to the lower falls seems to have been unimpeded; but in those times there was a saw-mill at the falls, supplied with logs rafted down the lake and floated over the upper falls, and the refuse of sawdust and slabs from this mill gradually choked up the channel until it became no longer navigable, in which condition it has remained to the present time. But under an appropriation made by the general government the channel is now being dredged out, and a depth of 7 feet will be obtained, so that canal-boats or propellers can come directly to the mills in the lower part of the village.

Ticonderoga is a pretty and flourishing place. A branch from the Delaware and Hudson Canal Company's railroad brings passengers in summer to the foot of the lake, and transports freight throughout the year. The village station is distant not over half a mile from most of the mills, and the uppermost of these is close by the track. The charges for freight were stated by one of the largest manufacturers to be very favorable.

At the extremity of the arm of the lake there is a natural abrupt fall of say 12 feet over a granite ledge. A dam 6 or 7 feet high has been built at the top of the ledge, controlling the lake and increasing the fall to about 18 feet. The dam is an old structure of timber, 60 or 65 feet long. The lake fills regularly in spring, and ordinarily reaches a height about 18 inches above the crest of the dam. It is said that wealthy owners of real estate on the shores of the lake will not permit its surface to be artificially sustained by flash-boards on the dam, and in consequence a large amount of water runs to waste in spring. The highest stage is gained in April or May, after which the level steadily declines until a minimum is reached in September. The water never rises more than about 2 feet above the crest of the dam, and never sinks more than about 1 foot below it. It falls to the crest usually by August 1, and remains below until November or December.

There is no association of the mill-owners here, but the discharge from the lake is controlled entirely by the proprietor of the upper privilege. He endeavors to pass down uniformly what he considers to be the natural flow. Many of the establishments below are small or of but moderate size, and for these the supply is commonly sufficient; but some of the larger concerns are short of water in the fall. The flow from the lake does not appear to be managed in the most economical manner. As has been said, there is a large wastage over the dam in spring, and, considering that there is a deficiency of supply in the fall, and that the raising of the dam by flash-boards or otherwise is not allowed, it would certainly seem better policy to draw down the lake another foot or two in the dry season, and so make the discharge entirely uniform throughout the year. The head at the upper falls would be but slightly diminished, and the loss would be largely compensated by the increased volume in low water.

The actual discharge from the lake has been repeatedly measured, (*a*) and found to vary between an ordinary maximum of about 660 and an ordinary minimum of about 330 cubic feet per second, although a few years ago it fell even lower than this. July 10, 1880, the flow was at the rate of 580 cubic feet per second, although the two preceding years had been unusually dry and the volume in consequence somewhat diminished. The rainfall on the drainage basin may be taken as, approximately, 9 inches in spring, 10 in summer, 11 in autumn, 8 in winter, and 38 for the year. Judging from the above figures for the maximum and minimum, the average discharge for the year may be estimated as not far from 450 cubic feet per second, which is equivalent to about 68 per cent. of the 38 inches of rainfall on the entire basin (including the lake surface) of 238 square miles tributary at the upper falls. It is stated that in 1839 Mr. William J. McAlpine made an examination of the water-power at this point, and measured the discharge as 429 cubic feet per second. This is presumed to have been before the lake was controlled by a dam at the outlet; but as neither that fact nor the stage of water is mentioned in the information at hand, the gauging is not perhaps of especial assistance in this connection.

In the report of Mr. McAlpine's survey the fall is given as follows: From the lake to the foot of the upper falls, 102.39 feet; thence to Trout Brook inlet, 26.27 feet; thence to water-surface in the bay communicating with lake Champlain, 91.43 feet; making a total of 220.09 feet. Mr. D. M. Arnold states the fall from water-surface in lake George to that in lake Champlain to be about 230 feet, which is of course liable to some variation with the stages of water in the two lakes. (*b*)

It is easy to see that the opportunities for the use of water-power afforded by the outlet of lake George must be very fine. The valley is open and perfectly accessible throughout the length of the falls. Railway communications are favorable. The lake holds back the water so as to insure entire immunity from freshets, and yields a remarkably uniform flow. It usually closes with ice between Christmas and the last of January, and opens in the month of April. The warmth of its water is such that anchor-ice seldom gives any trouble, and then only for a day or two during exceptionally cold weather, when the ground is bare and frozen hard. In addition to these advantages the water is very clear and soft, and thus well suited to use in paper-manufacturing.

Descending from the lake the privileges met are, in order, as follows:

1. At the outlet is a power owned by George C. Weed and leased by the Lake George Pulp & Paper Company. The fall is 18 feet. On the right bank is a small saw-mill with 50 horse-power of wheels, and a fine new paper-mill. The latter was nearly completed when visited in November, 1882, and was soon to start in the manufacture of news-paper, with a capacity for producing 4 tons per day. The mill has 290 horse-power of wheels, and is designed for the manufacture of either news-, wall-, or manila-paper. On the left bank is a dry-pulp mill using 150 horse-power. In the year before it was visited its production was 200 tons of pulp, and it has a capacity for 600 tons.

2. Fall of 18 feet owned and operated by the same parties as above; 250 horse-power of wheels is used in

a For knowledge of the results obtained, and for much general information concerning the lake and the water-power of its outlet, thanks are due to Mr. D. M. Arnold, civil engineer, of Ticonderoga.

b As we have seen, lake George is subject to an extreme variation in surface-level of about 3 feet. Lake Champlain loses largely in summer by evaporation and drainage, getting very low toward the end of the season and rising high again in late spring; it is thus subject to an annual oscillation of about 8 feet.

grinding wet pulp, of which the production is 2 tons per day. The tail water from the saw-mill on the upper fall is utilized on the second fall, under a head of 12 feet, by George C. Weed's planing-mill. About 40 horse-power is estimated to be obtained from an old scroll-wheel.

3. Immediately below the second privilege a low rude dam, a couple of feet high, diverts a portion of the water of the stream into a race on the right bank. The race is continued by an open wooden flume 6 or 7 feet wide and 300 feet long. From the extremity of this, water passes on a heavy incline through an iron tube down to the cotton-mill of the Lake George Manufacturing Company. The tube is 5 feet in diameter, $\frac{3}{16}$ of an inch thick, and about 240 feet long. The company owns about 75 feet of fall and half the flow of the creek. The head actually utilized is 68 feet, under which two Swain turbines of 400 aggregate horse-power are run, the two wheels acting upon a single vertical shaft. Only 175 or 200 horse-power is in active use, and of course not nearly all the water of the creek. The company employs 150 hands, runs 10,000 spindles and 252 looms, and manufactures fine sheetings, of which its production is 55,000 yards per week. The other half of this privilege can be improved in a manner similar to that just described, and would furnish a splendid power. It is owned by the American Graphite Company, which has works at the lower falls in the village.

4. Succeeding the 75 feet owned by the Lake George Manufacturing Company there is an available unimproved fall of about 13 feet, owned on the east side by W. E Calkins and the Glens Falls Pulp Company, and on the west by W. E. Calkins and the heirs of John Lewis, deceased.

5. A fall of 13 feet, owned and used by the Glens Falls Pulp Company in the manufacture of mechanical wood-pulp from poplar and spruce. This company employs 250 horse-power of wheels and turns out about 800 tons, dry weight, of pulp in the course of a year. Ordinarily the supply of water is ample throughout the year, but for a couple of months, say once in five years, the manager states that the works can be run at only one-half or three-quarters of their full capacity. The dam is of log crib-work and stone. A small trout-brook, 6 or 8 miles long, empties into the mill-pond, and is of considerable assistance at times, though not of much use in low water. It may be said in general of the water-privileges on Ticonderoga creek that the dams are short, cheap, and unimportant. The pondage formed by them is very small, and in most cases of no consequence whatever.

6. By means of a low dam of timber and stone and a short wooden flume, water is diverted to S. J. Moore & Son's 3-run grist-mill, where 56 horse-power of wheels is run under a fall of 6½ or 7 feet.

The stream now divides, and a small branch running off to the right incloses an island and then joins the main creek again, furnishing power in the interval to Hooper & Co.'s machine-shop, Patterson & Merchant's grist-mill, and two other small establishments. Continuing down the main stream, we have:

7. A fall of 5 feet, at which from 5 to 10 horse-power is used in J. W. Treadway's 1-set mill for the manufacture of plain and fancy cassimeres. A small race on the opposite bank supplies the sash, door, and blind factory of the C. P. Fobes Co-operative Union. This concern has a fall of about 8 feet and owns water for 25 horse-power, but uses only a small part of this.

8. A fall of 10 feet used in J. Q. A. Treadway's 2-set fancy-cassimere mill. About 25 horse-power is said to be employed.

9. Privilege known as the "island property", embracing a fall variously stated at from 30 to 40 feet, and utilized to only an insignificant extent in a little shop for re-cutting files. The privilege is a valuable one and offers a good building-site. It is owned by the Rogers estate and Burleigh Brothers, of Ticonderoga.

10. The main stream, having been rejoined by the small branch which forms the island, soon after passes over a low weir with a fall of 2 or 3 feet. A stout division-wall of masonry runs thence some distance down stream to the last dam. No power is used from the fall at the weir, and its only purpose is to divide the flow of the stream. It has a length of 75 feet, and the division wall is 50 feet from the right bank. Consequently two-thirds of the flow passes down to the right and one-third to the left. The privilege at the lower dam yields an effective fall of 30 feet, and is utilized on both sides of the river. On the right bank are the works of the Ticonderoga Pulp & Paper Company. This company previously had a mill here for grinding wood-pulp, and in November, 1882, had just completed a fine new mill for chemical pulp, with a capacity for producing about 5 tons per day. On the left bank are the works of the American Graphite Company, which were found to be shut down for the winter, and Cyrus Butler's iron-works, which were closed temporarily at least, and probably permanently. The Graphite company has 3 wheels with an aggregate of 165 horse-power; the iron-works receive water through a separate flume, and have 2 wheels furnishing together about 75 horse-power.

With this privilege the fall of the creek is practically finished and we are brought down to slack-water. From the description that has been given, it may be seen that the manufacture of pulp and paper is the most prominent industry on this outlet, and it is the one to which the locality seems best suited. There is evidently a large amount of fall either partially or entirely undeveloped. In particular, there is the fall in the upper village, owned by the American Graphite Company and embracing from 68 to 75 feet,(*a*) with half the flow of the stream; 13 feet immediately below which is entirely unemployed; and the "island property" in the lower village, with from 30 to 40 feet of fall. Besides

a It could not be definitely ascertained whether the property on the left bank covers more than the 68 feet of fall the power of which is utilized on the opposite side by the Lake George Manufacturing Company.

these there are various falls at which but a small proportion of the available power is put to use. From the best data at hand the power at the various falls may be estimated as in the table below:

Summary of water-privileges on Lake George outlet (in order from the upper falls), with estimate of available power.

Party owning or occupying privilege.	Manufacture.	Fall.	Theoretical horse-power, based on average flow for the 24 hours. Ordinary minimum. (a)	Ordinary maximum. (b)	Average for the year. (c)	Effective horse-power of wheels in use.	Remarks.
		Feet.					
George C. Weed owns privilege and leases to Lake George Pulp & Paper Company.	Dry pulp and news-paper manufactured, and small power used by saw-mill.	18	675	1, 350	920	490	Storage of lake controlled at the dam. Capacity of pulp-mill, 600 tons per annum; of paper-mill, 4 tons per day.
George C. Weed owns privilege and leases main portion to Lake George Pulp & Paper Company.	Wood-pulp ground, and small power used in Weed's planing-mill.	18	675	1, 350	920	290	Production of pulp-mill, 2 tons per day.
Owned and used on right bank by Lake George Manufacturing Company. The other half is owned by the American Graphite Company, and is not used.	Fine sheetings	*d* 75	2, 810	5, 620	3, 830	175–200	The privilege affords a splendid unemployed power. The cotton-mill has 10,000 spindles, 252 looms, and 400 horse-power of wheels in place.
Power on east bank owned by Glens Falls Pulp Company and W. E. Calkins; on west bank by W. E. Calkins and heirs of John Lewis, deceased.	Entirely unimproved	13	490	980	660	....	
Glens Falls Pulp Company	Mechanical wood-pulp	13	490	980	660	250	Production, 800 tons per annum.
S. J. Moore & Son	Power used for 3-run grist-mill.	6½–7	260	520	360	56	
On a branch striking off from the main stream just below Moore's mill are several small powers.	Power used in carpenter-shop, machine-shop, grist-mill, and wheelwright-shop.	....	....	....	....	100±	
C. P. Fobes Co-operative Union (right bank).	Sashes, doors, and blinds	....	....	....	....	10±	Takes water from same pool as J. W. Treadway, and returns it farther down stream.
J. W. Treadway (left bank)	Plain and fancy cassimeres.	5	*e* 170	*e* 360	*e* 240	5–10	One set of cards.
J. Q. A. Treadway	Fancy cassimeres	10	*e* 340	*e* 720	*e* 480	25	Two sets of cards.
"Island privilege", owned by Rogers estate and Burleigh Brothers.	Substantially unemployed	30–40	*e*1,020–1,360	*e*2, 150–2, 860	*e*1,430–1,910	....	Fine site.
Ticonderoga Pulp & Paper Company	Pulp and paper	} 30	1, 125	2, 250	1, 530	......	
American Graphite Company	....					165	Not running in the fall of 1882.
Cyrus Butler	Iron-works					75	Works closed.
Power on outlet for assumed fall of 1 foot	....	1	37. 5	75	51.12	....	In exceptional years the minimum power sinks below the figures here given. With suitable management of the storage in the lake the average flow from it could be made uniformly available through the year.
Total power on outlet, assuming fall at 220 feet.	....	220	8, 250	16, 500	11, 250	*f* 1,600–1,700	
Total power on outlet, assuming fall at 230 feet.	....	230	8, 625	17, 250	11, 760		

a Flow assumed at 330 cubic feet per second.
b Flow assumed at 660 cubic feet per second.
c Flow assumed at 450 cubic feet per second.
d Possibly the Graphite company's property covers but 68 feet of fall.
e The small branch running to the right of the island somewhat diminishes the volume of the main stream. For the three falls indicated the reduction has arbitrarily been assumed to be 30 cubic feet per second.
f Not including the power used by the Ticonderoga Pulp & Paper Company.

INDEX TO REPORT ON WATER-POWER OF HUDSON RIVER BASIN AND LAKE GEORGE OUTLET.

REPORTS ON THE WATER-POWER

OF THE

REGION TRIBUTARY TO LAKE ONTARIO.

AND OF THE

NEW YORK STATE CANALS,

BY

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SPECIAL AGENT.

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THE REGION TRIBUTARY TO LAKE ONTARIO.

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BOSTON, MASS., *July* 9, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York City.

SIR: I have the honor to submit a report upon the water-power of the region tributary to lake Ontario, based upon investigations carried on under your direction, mainly in the autumn of 1882. It is desired to call attention to the principles observed in the estimates of flow and power, which are fully explained in connection with the report on the region tributary to Long Island sound.

Very respectfully,

DWIGHT PORTER,

Special Agent.

REPORT ON THE WATER-POWER

OF THE

REGION TRIBUTARY TO LAKE ONTARIO.

THE REGION TRIBUTARY TO LAKE ONTARIO.

The principal rivers here to be noticed are the Black, Oswego, and Genesee.(*a*) These three drain an aggregate area of about 9,370 square miles, and minor streams increase the whole tributary area lying on the south shore of the lake, between the Saint Lawrence and Niagara rivers, to 12,400 square miles. To the southward are the basins of the Susquehanna and Allegheny. Certain tributaries of those rivers and the Genesee have their origin in common in Potter county, Pennsylvania, the drainage from which reaches the Atlantic ocean through such widely-separated channels as the gulf of Saint Lawrence, Chesapeake bay, and the gulf of Mexico. Striking southeasterly from fort Niagara and then southerly, the water-shed line inclosing the district we are considering passes around the head-waters of the Genesee, entering a little way into Pennsylvania, and reaching there its point of farthest removal from the lake, at a distance of about 95 miles. The division of the drainage slopes to the north and south is there effected by the elevated ridges which are thrown out as spurs of the Alleghany mountains. Re-entering New York state the line runs in an irregular course to the southward and eastward of the interior group of lakes; its elevation decreases, it turns to the northward, and east of Oneida lake sinks to an altitude of but 430 feet above ocean-level, forming a most favorable pass, through which the Erie canal crosses from the middle Atlantic slope to the basin of the great lakes. Around the sources of Black river the water-shed traverses the northern wilderness, and finally turning westward to Cape Vincent descends to the lake again.

The country thus included may be described in general as level or gently undulating in the counties bordering upon lake Ontario. To the southward it becomes more rolling, and a series of ridges gradually rising in height stretch down between Cayuga, Seneca, and their companion lakes, and finally become merged in the elevated and broken country forming the principal water-shed, the abrupt slopes of the latter attaining altitudes of from 2,000 to 2,500 feet above sea-level about the head-waters of the Genesee.

In the region inclosed between the summit line and the southern border of lake Ontario the gradual decline in level is accomplished by a succession of terraces, revealing in order the various geological formations from the more recent Devonian down to the older of the Upper Silurian. There is thus a progression downward from the shales and sandstones of the Portage and Chemung groups, in Allegany county, to the Medina sandstone bordering the lake in Monroe, and closely approaching or touching it in Oswego county. Owing to the soft character of many of the formations, changes have gone on which would have been impossible in a region of hard metamorphic rocks. Surface strata have become disintegrated and ground into soil. Tremendous masses have been torn and worn out in past ages by the action of glaciers and water, deep depressions have been formed which are now occupied by lakes, and narrow gorges have been cut for the streams. The latter preserve many high and vertical falls, but descents which were once probably made in single magnificent plunges near the mouths of the rivers have slowly receded, and in an uneven retrograde motion have become distributed up their courses in rapids and minor falls. To the eastward from the lake are found the sandstones, limestones, slates, and shales of the Lower Silurian strata, while still beyond are the granites and gneisses of the Archæan era.

Drift deposits are quite generally scattered over this section, the soil of which is derived in part from that source and in part from the disintegration of the native rocks. The fertility of the soil is great, and sustains a large annual production of the various grains. In those districts less suited to such use, or possessing especial advantages for dairying, wool-growing, and stock-raising, those industries take a prominent position. This region was once heavily clothed with timber, and considerable amounts still remain toward the Pennsylvania boundary, but to the northward the land has generally been cleared and only moderate patches of woods are left. The development of this part of New York state has been warranted by its rich resources, and has been fostered by the establishment of a fine system of water and railroad transportation. Running east and west is the Erie canal, joining the great lakes with the Atlantic seaboard and affording an outlet to numerous connecting routes on the interior lakes and canals. The New York Central and Hudson River railroad through the north, and the New York, Lake Erie, and

a The Niagara river is elsewhere described by Mr. Greenleaf.

Western railroad across the southern portion of the area here described, constitute two great lines between the east and the west, while various feeders and intersecting roads go to make up an extensive network.

Each of the three rivers, the Genesee, Oswego, and Black, possesses a large aggregate amount of water-power; each is already much utilized for manufacturing, and each offers opportunity for a considerable further development; but they differ widely among themselves in several important features. The Genesee has about a third more drainage area than the Black, and half that of the Oswego. Its fall is concentrated in a remarkable manner at Portage and Rochester, but elsewhere in the middle and lower course is only moderate in amount, while the volume is very variable and reaches a low point during the summer and fall. The Oswego is itself comparatively a short stream and its slope is not large, but it embraces within its basin a magnificent group of lakes which serve as storage reservoirs, and which maintain under all ordinary circumstances a very full and uniform discharge. The Black, although draining the smallest extent of country, is not equaled by either of the other main streams in the aggregate of valuable water-power which it offers. Its descent is rapid, both in the upper and lower course; an extensive portion of its basin is underlaid by metamorphic rock; its sources are back among the lakes and woods of the northern wilderness, and it flows with a large and steady volume even during the driest seasons.

In the main portion of the region tributary to lake Ontario on the south and east the average annual rainfall does not probably much, if at all, exceed 35 inches, and there is a range at different points from less than 30 to more than 40 inches. In the more elevated sections, and especially toward the head-waters of the Black river, the precipitation is thought to be greater than in the lower districts, but there are few records of long-continued observations. Regarding the fall of snow, it is stated in Blodgett's *Climatology* that—

In the basin of lake Ontario, as it is sometimes called—the lower portion, to which Auburn and Rochester are central—there is no regular quantity on the ground in winter, and for half the time, on an average, none remaining. But here and in southern New York there is great inequality, sometimes a winter occurring with very little, and at others immense quantities falling and remaining for several weeks. In extreme cases, of which the winter of 1855–'56 was perhaps the most conspicuous, from 3 to 5 feet in depth have fallen at one time over this basin or low plain, and still more on the highlands east and south.

Table showing the rainfall and temperature at points in the basin of lake Ontario.(a)

Locality.	Elevation.	RAINFALL.						TEMPERATURE.					
		Years of record.	Spring.	Summer.	Autumn.	Winter.	Year.	Years of record.	Spring.	Summer.	Autumn.	Winter.	Year.
	Feet.		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*
Sackett's Harbor	266	7	9.20	8.59	11.58	7.36	36.73	9	42.79	68.51	50.80	23.72	46.45
Lowville	847	23	6.96	10.04	9.09	7.46	33.55	24	42.69	65.12	45.89	21.55	43.81
Oswego	250	18	9.92	10.02	11.24	9.24	40.42	18	42.10	66.94	50.47	25.87	46.35
Syracuse	407	9	8.65	9.72	10.92	7.46	36.75	3	43.39	68.33	49.39	26.91	47.09
Ithaca	417	19	9.05	10.13	9.52	5.84	34.54	21	46.48	68.29	49.51	28.86	48.29
Penn Yan	740	39	7.09	9.28	7.45	4.49	28.31	31	44.28	66.82	48.53	26.53	46.54
Little Genesee	1,500	7	7.84	10.65	9.06	8.91	36.46	5	41.43	66.46	46.45	23.39	44.43
Rochester	500	45	8.05	9.12	9.27	7.21	33.65	39	44.72	68.04	49.02	25.46	47.06

a From Smithsonian records.

I.—THE BLACK RIVER.

This river is a striking example of the splendid water-power streams which find their sources in the northern wilderness of New York state, and which radiate thence to nearly all points of the compass. Its especial value for power arises from the favorable distribution of its fall, a full and remarkably well-sustained flow, firm bed and banks, an open and accessible valley in or adjacent to sections of valuable agricultural and mineral resources, and convenient facilities for transportation both by land and by water.

The Black river takes its rise in one or two small lakes in the western part of Hamilton county, whence it pursues a southwesterly direction for some 30 miles by general course, passing across Herkimer and into Oneida county; it then turns and runs somewhat west of north through Lewis county, after which the course lies westerly across Jefferson county to Black River bay, at the eastern extremity of lake Ontario. In an air line the extreme lake-source of the river is about 65 miles southeasterly from Watertown. By map measurement the actual length of the river's course, taking account of the bends, is 130 miles, and the drainage area is 1,857 square miles. This area must be regarded, however, as only approximately correct, for the geography of the region about the upper waters is too imperfectly known and portrayed on maps to admit of an accurate determination.

The section drained by the upper river in Herkimer and Hamilton counties is described as very rugged and mountainous, with many beautiful lakes scattered over its surface, the latter wooded and covered generally with a

light sandy loam having but little value for cultivation. The population is very sparse, and the entire township of Wilmurt, 16 miles wide and nearly 50 miles long, containing practically all of the Black River basin that lies in Herkimer county, had but 271 inhabitants in 1880. In the southern part of this township are illustrated, though to a less degree than in the upper basins of the Hudson and Raquette rivers, the great capabilities of the Adirondack region for reservoir storage. Within a radius of 5 miles there are a dozen lakes, of various sizes, the most important of which are controlled by state dams and have their waters diverted to the supply of the Erie and Black River canals, mainly the former. Some facts concerning the capacity and cost of these reservoirs are given in the following table:

State reservoirs in the upper Black River basin.(*a*)

Name of reservoir.	Surface flowage.	Average area for full depth.	Depth.	Capacity.	Supply for 100 days.	Cost.
	Acres.	*Acres.*	*Feet.*	*Cubic feet.*	*Cu. ft. per sec.*	*Dollars.*
Woodhull reservoir (requires two seasons to fill)...	1, 236	1, 118	18	876, 550, 000	101	26, 529
North Branch reservoir (can be filled twice yearly).	423	277	28	337, 800, 000	39	54, 894
South Branch reservoir...........................	518	372	26	421, 190, 000	49	....
Sand Lake reservoir..............................	....	306	15	200, 000, 000	23	34, 228

a Data taken from *Annual Report of the State Engineer and Surveyor*, 1867, and from *Annual Report of the Superintendent of Public Works* for the year ending September 30, 1878.

The storage from the North Branch and South Branch reservoirs descends through the main river, that from Woodhull and Sand Lake reservoirs through Woodhull creek, to Forestport, where there is a state dam below the junction of the two streams. From this point the water is conveyed 10½ miles in a feeder to the summit level of the Black River canal at Boonville, feeding thence northward toward Lyon's Falls, and southward to Rome, where it enters the Erie canal. There is thus directly controlled by the state for canal purposes about 275 square miles of the upper basin of Black river, and its natural drainage is mostly diverted southward during the dry season. So far as concerns the water-power of the river below Forestport this area may therefore be regarded as practically cut off, leaving an effective drainage area above the mouth of the river of only 1,582 square miles. Although for much of the year there is doubtless a considerable waste over the Forestport dam, yet in the dry summer months the storage above that point is scarcely adequate to meet the demands for maintaining canal navigation. In his report for the year ending September 30, 1879, upon the middle division of the New York state canals, (*a*) Mr. Marvin Porter, division engineer, stated that during the preceding season all the reservoirs of the Black River group had been drawn down, and presented several projects for gaining a greater storage in the future, including the construction of a dam 20 feet high at the head of the present pond at Forestport; such a dam would flow 700 acres to an average depth of 7 feet, giving a storage, in addition to the previous supply, of 213,444,000 cubic feet, which could be obtained twice yearly.

All the larger eastern tributaries of the Black river contain within their basins numerous lakes and ponds, and there can be little question that abundant opportunities exist for a substantial increase of the low-season flow of that portion of the main river which is especially available for manufacturing. The only improvements of this character of which any information is at hand are in the case of the Fulton chain, a remarkable series of eight lakes tributary to the north branch of Moose river. It is reported that dams have been erected by the state at the outlets of two of these lakes, but no special knowledge concerning them was gained.

From full-water level in the North Branch reservoir, which is on the upper course of the main stream, to the crest of the Forestport dam, there is a fall of 692 feet in 21.6 miles. Thence to the crest of the Lyon's Falls dam, a distance of 17 miles, there is a further descent of 327¼ feet, followed by an abrupt pitch of about 69 feet in less than 250 feet. The Black River canal, descending to Lyon's Falls from the summit level at Boonville, now enters the river, which changes its character wonderfully and for 42½ miles, to Carthage, is continuous slack-water, only interrupted by two low dams, and navigable. The entire descent in this distance amounts to but 9¼ feet. From a little above Lyon's Falls to Carthage the river increases its gross drainage area from 458 to 1,741 square miles, receiving in the intervening distance most of its important tributaries, including Moose and Beaver rivers and Independence and Otter creeks from the east, with Sugar and Deer rivers from the west.

At Carthage navigation comes to an end, but we reach the most valuable portion of the whole river for power. The volume is large and the descent rapid. From the crest of the Carthage dam to the water-surface of lake Ontario there is a fall of 477 feet, the distance being about 29½ miles. Of this fall 55 feet occurs in 4,600 feet at Carthage, and 122 feet in the 3½ miles within the limits of the city of Watertown. Throughout the section of river now under consideration the bed is almost continuously of solid rock. The banks are to a large extent of the same material and are of good height; in fact, the stream has, for considerable portions of its course between Carthage

a See *Annual Report of the State Engineer and Surveyor.*

and the mouth, and especially below Watertown, so cut its way into the rock formations that it runs in a gorge with steep rocky walls, but not in general so deep as to interfere with the development of powers. At Carthage the outcropping ledges are of the primary formation, consisting of granite and gneiss; farther down stream Isle la Motte marble, or Black River limestone, shows in the banks, but it is only about 8 feet thick, and the prevailing rock material is the Trenton limestone.

The country east of the river in Lewis county rises gradually to a plateau, and on the adjacent border of Herkimer county has an elevation of some 1,400 feet above tide. It is frequently traversed by low ridges of gneiss, and possesses a poor, sandy soil. Iron sand is stated to be found along the streams, and magnetic and red specular ores of iron occur interstratified with gneiss on the northeastern border of the county.(a) The tributary streams are discolored by organic matter, manganese, and iron, and give to the main river that dark color which fully justifies its name. To the west of the river there is a rise, by successive terraces, to elevated table-lands from 1,500 to 1,700 feet above the sea. The Trenton limestone underlies a very fertile strip of land, from 1 to 3 miles wide, running in a north-and-south direction. Farther west the limestone formation is succeeded as the surface rock by Utica slates and Lorraine shales, which rise some 500 feet higher and are covered by a level summit region containing extensive swamps; the shales are easily decomposed and form a rich soil. Deposits of drift are also scattered throughout this section, and in some localities are very deep. On the north side of the Black river, in the towns of Wilna and Le Ray, Jefferson county, this formation contributes the material of a pine plain, sandy and barren, said to measure 14 miles in length by 4 miles in average width. In the town of Antwerp, which adjoins Wilna on the north, there is an abundance of iron ore. Barley, oats, corn, wheat, and grass are the leading productions of the soil in Jefferson and the western half of Lewis counties, but though fine crops are obtained, and in the vicinity of Watertown a yield of from 25 to 40 bushels of wheat to the acre is not uncommon, dairying is considered more profitable than the raising of grains, and is indeed the principal industry of the people.

Water-power is utilized on the lower river at Carthage, Great Bend, Felt's Mills, Black River, Watertown, between there and Brownville, at the latter place, and at Dexter. Many of the wheels used at the various privileges are old-fashioned and very wasteful, the dams and flumes are often leaky, and thus the best results are not obtained from the water at command. At Watertown and Carthage the available power of the river is especially large, and the manufacturing interests are far more extensive and diverse than at the other localities mentioned; but even there the use of power might be much increased, while it is true of the section of river from Carthage to the mouth, as a whole, that about one-half of the fall is entirely unimproved. Watertown is a fine city of between 10,000 and 11,000 inhabitants; Carthage has a population of 1,900, but the other manufacturing points referred to are unimportant villages, Brownville and Dexter numbering only from 400 to 500 inhabitants each. As we have seen, navigation by slack-water extends from Carthage to Lyon's Falls, and by the Black River canal thence to the Erie canal at Rome. Railway communication is also afforded by the Utica and Black River railroad, which follows down the valley of the river from Boonville to the lake, and by the Rome, Watertown, and Ogdensburg railroad, which crosses at Watertown.

Table of elevations on Black river and tributaries.

Stream and locality.	Distance from mouth of Black river.	Height of water-surface above mean sea-level.	Distance between points.	Fall between points.	Fall per mile between points.	Authority for elevation.
Beaver river.	*Miles.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*	
Beaver lake (No. 4), in Lewis county	59.0	1,435.97	20.0	712.27	35.61	Colvin—Adirondack survey.
Mouth of Beaver river	39.0	723.70				Estimated from elevation of Black river at Carthage.
Moose river.						
Big Moose lake	....	1,787.00	....	....	....	Colvin—Adirondack survey.
Little Moose lake	....	1,772.00	....	....	....	Do.
Eighth lake, Fulton chain	....	1,803.00	....	41.00	....	Do.
Seventh lake, Fulton chain	....	1,762.00	....	2.00	....	Do.
Sixth lake, Fulton chain	....	1,760.00	....	69.00	....	Do.
Fifth lake, Fulton chain	....	1,691.00	....	4.00	....	Do.
Fourth lake, Fulton chain	....	1,687.00				Do.
Third lake, Fulton chain	....	....	....	3.00	....	
Second lake, Fulton chain	....	1,684.00	....	0.00	....	Do.
First lake, Fulton chain	102.6	1,684.00	30.5	882.22	28.93	Do.
Mouth of Moose river	72.1	801.78				Estimated from elevation of Black river at lock No. 109, foot of Lyon's falls.
Black river.						
South Branch reservoir	....	2,019.00	....	....	....	2,019 feet + tide-water, by New York canal profiles.
Woodhull reservoir	....	1,854.00	....	....	....	Colvin—Adirondack survey.
Chub lake	....	1,599.00	....	....	....	1,599 feet + tide-water, by New York canal profiles.

a Gazetteer of New York.

Table of elevations on Black river and tributaries—Continued.

Stream and locality.	Distance from mouth of Black river.	Height of water-surface above mean sea-level.	Distance between points.	Fall between points.	Fall per mile between points.	Authority for elevation.
Black river—Continued.	*Miles.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*	
North Branch reservoir	110.7	1,821.00				Colvin—Adirondack survey.
			21.6	691.97	32.04	
Crest of state dam at Forestport	89.1	1,129.03				By New York canal profiles 1,126.96 feet + mean tide (here assumed to be mean low tide at Albany).
			17.0	327.25	10.25	
Crest of state dam at Lyon's Falls	72.1	801.78				Estimated from elevation at foot of falls as given by New York canal profiles.
			....	69.00	....	
Foot of Lyon's falls (smooth water opposite lock No. 109).	72.1	732.78				Water-surface at lock No. 109 is given by canal profiles as 730.71 feet + mean tide; by Colvin's survey as 738 feet + sea-level. Fall occurs in 250 feet.
			42.5	9.25	0.22	
Crest of state dam at Carthage	29.6	723.53				721.46 feet + mean tide, by New York canal profiles.
			0.9	55.00	....	Fall occurs in 4,600 feet.
Foot of rapids at Carthage	28.7	668.53				
			....	4.33	....	
Utica and Black River Railroad crossing.	28.2±	664.20				By Utica and Black River Railroad profile rails at crossing are 686.2 feet above mean sea-level.
			11.2	101.10	9.03	
Felt's Mills, crest of dam	17.0	563.10				By Utica and Black River Railroad profile rails at Felt's Mills station are 616.4 feet above mean sea-level.
			6.6	70.97	10.75	
Watertown, upper city boundary, at head of falls.	10.4	492.13				Approximate elevation obtained by adding 122 feet to the altitude at the lower city line. By the profile of the Utica and Black River railroad the rails are 511.6 feet above mean sea level where the road crosses the highway shortly above Huntingtonville, according to which the elevation of the adjacent water-surface would be about 491 feet.
			3.5	122.00	34.86	
Watertown, lower city boundary	6.9	370.13				F. A. Hinds, civil engineer, gives the elevation as 123.52 feet above the surface of lake Ontario.
			6.9	123.52	17.90	
Mouth of Black river	0.0	246.61				As stated at the office of the Chief of Engineers, U. S. army, "the mean surface of lake Ontario, from January 1, 1860, to December 31, 1875, is 246.61 feet above mean tide at New York".

So far as can be learned, there are but few data from which to judge of the discharge of this river. March 22, 1875, the volume was measured at Watertown by Mr. Frank A. Hinds, civil engineer, and found to be 9,946 cubic feet per second; but the stream was then much above its average stage, the flow corresponding to which was assumed, as the mean of estimates by four persons long familiar with the river, at two-thirds the above amount, or 6,630 cubic feet per second. This assumption for the average flow, however, must be far from the truth, for it corresponds to the condition of a rainfall of about 50 inches over the entire tributary drainage area, *all* carried off through the channel of the river, with no allowance whatever for loss from evaporation and other sources.

At the privilege a short distance below Watertown occupied by C. R. Remington for the manufacture of paper, there is a fine new dam, which is tight, and which, acting as a weir, presents a fair opportunity to approximately measure the volume of the river. The roll-way is 650 feet long, with a sharp crest, a vertical face, and a back slope of 3 base to 1 vertical. During the dry summer of 1882 the least depth of water on this dam, measuring from the level surface of the pond, was 6 inches, and November 22 it was 7 inches, 900 horse-power of wheels running at full capacity under a head of 30 feet in each case. Assuming 310 cubic feet per second as used by the wheels, and 720 cubic feet as equivalent to 6 inches on the dam, then the minimum flow during that season may be considered to have been at least 1,030 cubic feet per second.

Data concerning the discharge of Black river.

Locality.	Natural drainage area.	Effective drainage area. (*a*)	Date, and stage of river.	Approximate discharge.	Discharge per square mile of effective drainage area.	Remarks.
	Sq. miles.	*Sq. miles.*		*Cu. ft. p. sec.*	*Cu. ft. p. sec.*	
Carthage	1,741	1,466	Lowest water in summer of 1882	1,070	0.73	2 feet depth on two weirs of 60 feet each. Waste on dam said to be small, and neglected.
Watertown	1,816	1,816	March 22, 1875, flow estimated to be one-half above average stage.	9,946	5.48	Measurement by F. A. Hinds, civil engineer.
Between Watertown and Brownville.	1,830	1,555	Lowest water in summer of 1882	1,030	0.66	900 horse-power of wheels running under 30 feet head, and 6 inches of water on dam 650 feet long.
Do	....	....	November 22, 1882, low stage	1,210	0.78	Same as above, with 7 inches on dam.

a Deducting, for the dry season, the 275 square miles tributary above Forestport, controlled by the state and having its drainage mainly diverted to the Erie canal.

At Carthage practically all the water used by mills from the upper level passes into the race-ways over two submerged weirs, each 60 feet long and sunk 2 feet below the crest of the dam. At the lowest stage in the summer of 1882 water was barely running over the top of the dam. Neglecting that wastage, and supposing the water in the race-ways drawn down a foot or more below the crests of the weirs, as was stated to be not uncommonly the case in the dry season, so that they are no longer submerged, then the probable discharge of the river appears to have been at least 1,070 cubic feet per second.

On the whole, the low-water flow of the river at Carthage and below, in an ordinarily dry season, may safely be taken at from 1,000 to 1,100 cubic feet per second, average for the twenty-four hours.

Although, taking the year through, Black river is a very steady stream, it is at times visited by large and sudden rises. At Brownville, but a few miles from the mouth, it is said that the effect of a heavy rain in the upper waters is usually felt on the third day, and that the river continues rising about forty-eight hours after the storm is over. Spring freshets generally occur in April, and the river runs lowest from August to November. Difficulty was experienced in ascertaining what effect had been produced upon the stream by the storage said to have been effected in the Fulton chain of lakes. A prominent manufacturer at Watertown was not aware that any especial improvement had been noticeable there, but at Great Bend it was confidently maintained that the dry-season flow had been visibly benefited. Anchor-ice troubles more or less along the stream, and at Watertown has occasionally forced a stoppage of the Remington paper-mills for a few hours. Heavy surface-ice forms in winter; in the lower river 2 feet is the common thickness, but 5½ feet is stated to have been observed one year. At Watertown this ice is well broken up in going over the various falls; at Black River it usually rots in the pond before going out, but there and at other points dangerous runs at times occur, aggravated in some instances by gorges.

Natural drainage areas of Black river and tributaries.

Stream and locality.	Drainage area.	Stream and locality.	Drainage area.
	Sq. miles.		*Sq. miles.*
Black river:		Sugar river	66
Above mouth of Woodhull creek	174	Moose river	349
At Forestport state dam	275	Otter creek	60
At Lyon's Falls, below Moose river	807	Martin's creek	29
At Carthage	1,741	Independence creek	90
At Watertown	1,816	Lowville creek	34
At mouth	1,857	Beaver river	365
Woodhull creek	96	Deer river	107

Water-powers.—Above Lyons Falls the river is described as being a succession of rapids, with occasional use of power by saw-mills and tanneries. At the falls there is a fine privilege, which had just been purchased at the time it was visited, with the design of developing it in the spring of 1883. Large manufacturing works were then to be erected, and the balance of the power above their requirements was to be held for disposal to parties who might wish to locate other establishments there. The Utica and Black River railroad has a station near at hand, and water communication is also afforded northward by the river to Carthage, and southward by the Black River canal to the Erie canal at Rome.

At the head of the falls the state has a timber dam about 500 feet long, and at the most not over 6 feet high from the bed-rock. The water passing over this dam flows in rapids for less than 200 feet, and then being collected in two narrow clefts in the rock, from 10 to 20 feet wide, one near the east bank and one near the west, plunges suddenly down 50 or 60 feet in a most beautiful fall, and is received into a deep pool below. From the crest of the state dam to the foot of this pitch the horizontal distance does not exceed 250 feet, while the vertical descent was found by measurement at the canal locks to be about 69 feet down to smooth water. The canal passes down the left bank around the falls, and then enters the river again, where it terminates. The banks adjacent to the falls are masses of solid rock, that on the west sufficiently sloping for the convenient location of a mill, but becoming abrupt a couple of hundred feet below; the east bank is rather steep opposite the falls, but a little way down stream has a more gentle descent. The site is a magnificent one naturally for the development of power, and it seems strange that it should not have attracted more attention. In a low stage practically the entire flow of the river is confined within the two narrow fissures in the rock at the top of the falls, and it is a comparatively easy matter to control either or both of the channels, and thus to utilize the whole volume of the river not required for the purposes of navigation. At the same time the sites for mills would be entirely out of reach of freshets and ice. On the west bank a wooden flume runs 60 or 70 feet to a little saw-mill having a single saw, but otherwise there is no evidence of any power ever having been used at the falls.

This privilege is owned by Mr. G. H. P. Gould, of Lyon's Falls. He states the descent from the foot of the state dam to smooth water below the falls as 64½ feet. He has had the volume passing over the dam measured by

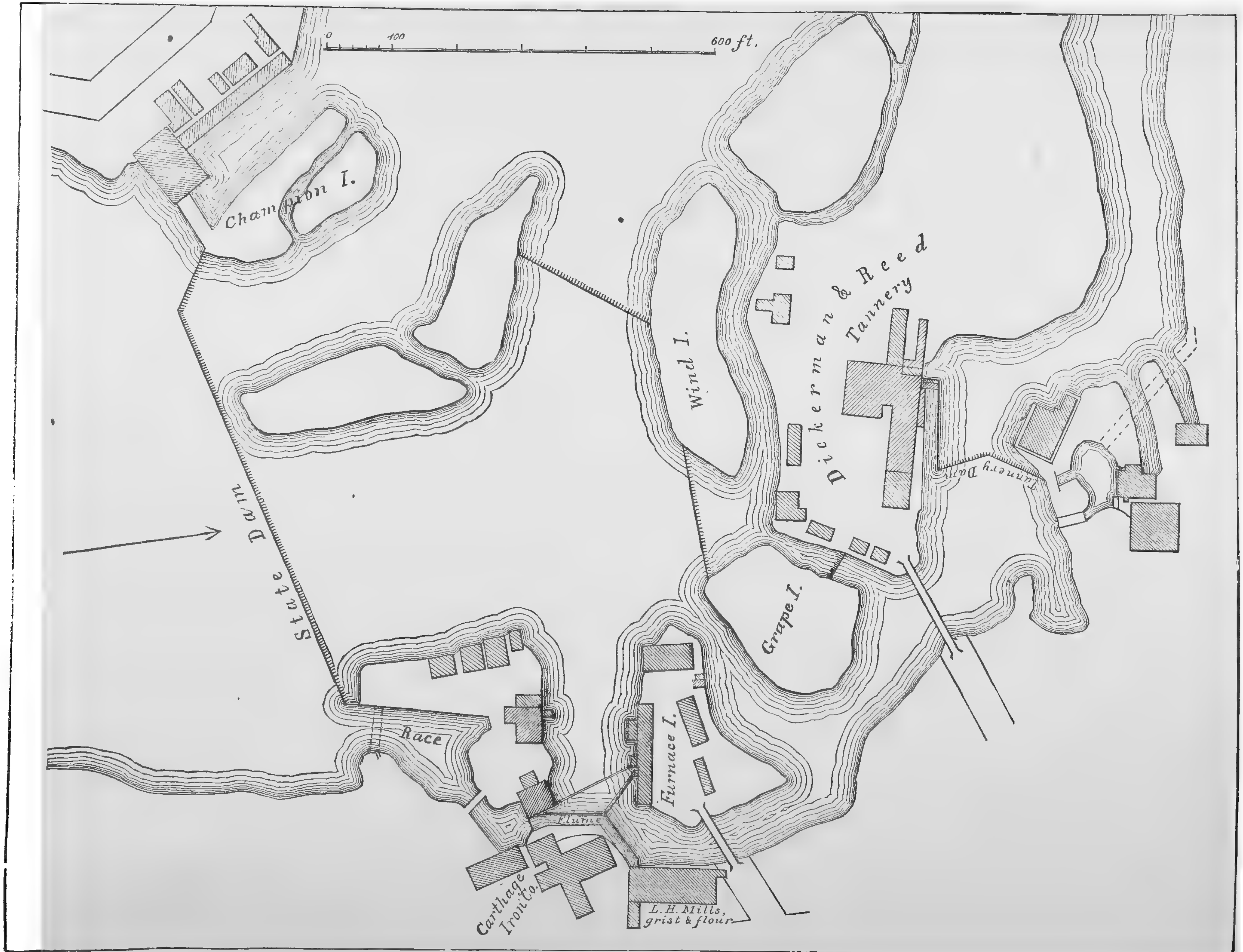

FIG. 1.—The Black river at Carthage.

an engineer, and upon the result obtained bases an estimate of the total available power in a low stage of river, which he puts at 4,000 effective horse-power. In the manner elsewhere explained the theoretical power of the river at this point in various stages may be estimated as below:

Estimate of power at Lyon's Falls.

Stage of river.	Rainfall on basin. (a)					Natural drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*64½ feet fall.*	*69 feet fall.*
Low water, dry year	9	10	12	8	39	*b* 807	260	29.54	1,900	2,040
Low water, average year							360	40.90	2,640	2,820
Available 10 months, average year							420	47.71	3,080	3,290

a Roughly estimated; no data for accurate determination. *b* Effective drainage area in dry season, 532 square miles (see page 5).

At Lyon's Falls the valley is open, with a gradual rise to distant high hills. Thence down to Carthage the stream lies in broad flat meadows, with extensive marshes and peat-swamps. The slack-water navigation which exists for the 42½ miles of this interval is maintained for 25 miles, more or less, above Carthage by a dam at that place, and for the remaining distance by two low dams a few miles apart. In low water boats are locked around the ends of these latter, but in high water are run over their crests; no power is used at either. The navigation over this section is small in amount and is mainly for the transportation of lumber.

At Carthage an important amount of manufacturing is sustained by the power which the river affords, and is mainly grouped about the state dam at the head of the falls. The river is there wide, with a bed of solid rock having a considerable dip to the northward, in which direction the stream also runs. Below the dam the channel is divided by a great many islands, varying much in size, low and rocky, and between which the river courses in rapids and falls, with a width between banks amounting in places to 1,000 or 1,500 feet. From the crest of the state dam to the foot of Decatur island, 4,600 feet below, there is a descent of 55 feet.

The dam is a timber structure, resting throughout upon rock; the overflow is about 770 feet long, and not more than 7 feet high at the highest point. As slack-water navigation terminates here, the only canals leading from the pool are those conveying water for power. But in order that the level above the dam shall not become too much reduced by the draughts for the mills, the withdrawals of water from the pool are compelled to be made over weirs, or "drops", as they are called, at either end of the dam, 60 feet in length and 2 feet lower than the crest. The amount of water available for manufacturing at the upper mills is therefore restricted to what will pass over these weirs. But on either side of the river there are numerous concerns employing this water and running very wasteful wheels. In low stages of river they draw down the races and connecting flumes faster than the weirs can supply them, the working head becomes greatly reduced, and much trouble is experienced.

On the east side of the river power is used as follows: An independent flume carries water to a small shingle-mill, while the main race supplies seven different establishments. The principal of these are the works of the Carthage Iron Company, production 15 tons per twenty-four hours when running, but which were shut down in the latter part of November, 1882; and the machine-shop and foundery of Ryther & Pringle, giving employment to 28 hands. The other concerns are of small or moderate size, and comprise two flouring- and grist-mills, one of 4 and one of 3 runs, a saw-mill, a furniture-shop, and a wool-carding shop. The fall obtained is 7 or 8 feet.

By means of four sections of dam extending out from the shore and from one island to another, a second level is formed below and entirely independent of the one just described, and commanding sufficient water to supply, on the main bank, the works of the Empire Steam Pump Manufacturing Company, employing 14 hands, and having a fall of 9 or 10 feet; and, on an island, the tannery of Messrs. Dickerman & Reed, having 6 feet of fall and 250 estimated horse-power of wheels. This latter firm tans from 15,000 to 16,000 hides yearly.

Perhaps a quarter of a mile farther down stream a rude crib-work dam, with a maximum height of not over 5 feet, is extended along from an island some distance parallel to the adjacent east bank, the water being retained next that bank, which is low, by a dike of loose stone with plank facing. The water then enters a wooden flume and runs say 250 feet to the Carthage Pulp Works, where a fall of 9 feet, and 3 wheels with an aggregate of about 120 horse-power, are in use. The production of the mill is 1½ ton per day.

A little farther down, a portion of the flow of the main stream is again confined between the east bank and an island, by means of a dam not more than 80 or 90 feet long running out between them, and on the main bank is Branaugh's tannery, with a fall of 10 or 11 feet, employing 18 hands.

An eighth of a mile below, the islands come to an end, the river has a single broad channel with gravelly rapids for a couple of hundred feet, and is then smooth water. At the foot of the falls the immediate banks are from 10 to 15 feet high, alluvial on the east side, and sandy on the west, though some rock is displayed there.

On the west side of the river the main race from the dam is continued as a wooden flume 7 feet deep and decreasing in width from about 20 to about 8 feet. The head ranges from 9 feet near the dam to 14 feet or more

toward the end of the flume. Power is utilized by a number of small mills and shops, including two saw-mills, a 3-run flouring-mill, a tannery, and shops for the manufacture of tubs and pails, sashes and blinds, and cabinet-ware; the firm of H. D. Farrar & Son employs 14 hands, and turns out an average of about 200 butter-tubs daily.

Succeeding this fall is a privilege on the same side of the river, owned by M. P. Mason. A timber dam 6 or 7 feet high and some 300 feet long runs out to an island, and gives a fall at the mills on the main shore ranging from $7\frac{1}{2}$ to 11 feet, according to position along the race. The power is employed to operate a 2-set hosiery-mill, 2 shops for making map-rollers and duster handles, one of them having a planing-mill in connection; and a shop for the manufacture of sounding-boards and other piano materials. One good site still remains vacant, and another can be made available by prolonging the race a little way, at both of which a moderate amount of permanent power can be realized.

On the levels opening out from either end of the state dam there is no chance for a further use of permanent power. Even now the supply of water is sometimes short in the dry season, and if it were sufficient for the legitimate needs of the mills, yet the lack of definiteness observed in the water-leases would prove, to many, reason enough for not starting a new enterprise. The present manufacturers are said to have priority of right to water in a low stage in the order of their leases. In those leases no definite amounts of water are specified, but each party is allowed a right to whatever amount he needs in his particular business. Thus water enough is granted to supply a grist-mill of a certain number of runs, or a saw-mill, or a cabinet-shop. In practice each mill-owner draws all the water he can get, up to the limit of his wants, and disputes are frequent.

But a privilege established independently below the upper mills has a great advantage: It will receive a certain proportion, according to position, of the tail-water from those mills, and at nearly all times there is also a wastage over the crest of the state dam, the benefit of which will also be gained. There seems to be no opportunity for developing such a privilege adjacent to the east bank; but below Mason's privilege, on the west side, there are fine sites which might easily be improved. Similar chances also exist among the islands out in the stream. Thus at the end of the island on which Dickerman & Reed's tannery is located there are falls with a descent of 10 feet in 200, and several feet more could be obtained by starting a little farther up stream. The powers realized at such sites would of course vary in size according to the fall and the proportion of the river's flow commanded, but probably very little difficulty would be experienced in obtaining them of moderate amount. The current is so rapid among the islands that the freshet-rise is small, amounting to but 2 or 3 feet.

Estimate of power at Carthage.

Stage of river.	Rainfall on basin. (a)					Natural drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Total effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*55 feet fall.*	
Low water, dry year	9	10	12	8	39	b1,741	1,000	113.6	6,250	1,120±
Low water, average year							1,250	142.0	7,810	
Available 10 months, average year							1,350	153.4	8,440	

a Roughly estimated; no data for accurate determination. b Effective drainage area in dry season, 1,466 square miles (see page 5).

From Carthage to Great Bend, 10 miles by river below, there are no dams, though the fall is considerable. Between the former point and Madame De Ferriet's bridge Rawson's dam was formerly located, but was carried out by a spring ice-freshet about 1870. The dam was a log structure 16 feet high, well pinned together, filled in with stone, and part of the way bolted to bed-rock. The power was used in a small saw- and shingle-mill. By a low dam at the head of the rapids, and a flume say 600 feet long, a fine power could be developed here, and the banks are well suited to such improvement.

At Great Bend the river is only 60 or 80 feet wide, with high precipitous banks on the north side, and is controlled by a log dam built on rock and varying in height, but at the highest point measuring about 14 feet, which is also the extreme head obtained at the mill. Two wheels, with an aggregate of 150 or 160 horse-power, are run by the Great Bend Paper Company, manufacturer of hanging-paper, of which it produces an average of 3 tons per day. The company controls the whole privilege, has abundance of water for its own needs, and also a large surplus.

Below Great Bend the river runs quite straight and with a fair amount of fall on toward Felt's Mills, $2\frac{1}{4}$ miles below. The banks along this section are vertical walls of rock. At Felt's Mills an island forms two channels, across each of which is a dam, the longer section, that across the south channel, being a log structure 13 or 14 feet high above foundation and in the neighborhood of 175 feet long. The north channel is about 175 feet wide at the road bridge, but is not used for power. On the island there is a small saw- and shingle-mill, and C. C. Veber's tannery, at which about 8,000 hides are tanned yearly. Three water-wheels are run under a head of 9 feet. On the south side of the river is B. Felt's grist-mill, 3 runs, fall 8 or 10 feet; and Roberts & Flagg's factory for making ax-helves and other handles. At this establishment four hands are employed usually, and from 10,000 to 12,000

dozen ax-helves, and half that number of other handles, are turned out yearly. Mill creek empties into the flume on that side of the stream, and though it carries but little water in summer, is fed by springs, and keeps the grist-mill race free from ice in winter by the warmth of its waters.

At Black River, 7 miles by road above Watertown, the river is divided by islands into two principal channels. Two islands, one below the other, are joined by a short section of dam, and each island is connected with one of the banks, the whole stream thus being controlled. The principal section of dam is across the right branch, and is a log structure 13 feet high, from 200 to 250 feet in length, and presenting an angle up stream. The bed of the river is solid rock, with a sudden pitch of several feet below the dam. A wooden flume extends from the latter 600 or 800 feet down the right bank and supplies three concerns with water for power, while others are located on the opposite bank and on one of the islands. The fall from the top of the dam to the surface of the pool below is about 16 feet. At this privilege, as at others on the river, water is not economically used, and in low stages there is no waste on the dam. The principal manufacture here is of chairs, in which two firms are engaged; pine is obtained from Canada, and hard wood, mainly beech and maple, from the vicinity of Black River. Poor, Dexter, & Co. manufacture rockers and folding-chairs, using a fall of 10 feet, and two wheels of 30 or 40 horse-power each. They give employment to 25 hands, and turn out 20,000 chairs per year. D. H. Scott & Son employ 10 hands in putting together stock made by the above firm, using a fall of 12 feet, and 40 or 50 horse-power. D. Dexter's Sons also manufacture chairs, their mill having been started in 1839; they employ 35 hands, and their production amounts in value to about $35,000 per year. The firm of J. S. & E. E. Graves makes bent stock and chair-backs, and employs 12 hands. There is also a 4-run flouring-mill here, and a cabinet-shop, blacksmith-shop, and shingle-mill use small powers.

Estimate of power at Black River.

Stage of river.	Natural drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse power of wheels in use.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	16 *feet fall.*	
Low water, dry year	a 1, 794	1, 040	118. 1	1, 890	265 ±
Low water, average year		1, 290	146. 5	2, 340	
Available 10 months, average year		1, 390	157. 9	2, 530	

a Effective drainage area in dry season, 1,519 square miles (see page 5).

A short distance below the village there is an unoccupied privilege, formerly in use for a wood-working shop employing a few hands. The dam was about 11 feet high, but in January of 1878 or 1879 an ice-gorge, formed at some point above and coming suddenly down, carried the structure away. The privilege is owned by Messrs. John W. Huntington, of Mexico village, and G. W. Pennock, of Chaumont, and is held for sale. The banks are smooth sloping faces of Isle la Motte marble, on which ordinary freshets rise 8 or 9 feet above low water, and high ones 10 feet. The old dam was located at the top of a pitch of several feet, below which rapids extend to falls to be described. A small wooden building still stands on the left bank.

A little farther down another fall begins, and in 600 or 800 feet there is a descent of about 15 feet, mainly in a single steep pitch in the upper portion. Below this fall, and not more than one-half or three-quarters of a mile from the Black River mills, there are three falls, 300 or 400 feet apart, and covering together a descent of about 15 feet as shown by pocket-level. The river is here from 75 to 125 feet in width, the banks are 15 or 20 feet high and composed of shelving rock, and the site is in every way an excellent one.

The surrounding country in this section has a fertile dark-colored soil, is moderately timbered, and is characterized by long slopes and a generally level appearance. The stream is somewhat divided by islands, and there are three of large size between Black River village and Huntingtonville, a few miles below. From a point a mile or a mile and a half below the former, down to the latter village, there are now and then slight ripples, but the fall is small, and the right bank is low not far above Huntingtonville. At that locality, a small village of scattered houses say 2 miles above Watertown, power was formerly used in a saw-mill and in a scythe and ax factory. A large island of 90 acres divides the river into two channels, both of which were dammed. The main channel is to the left of the island, with a width of perhaps from 200 to 250 feet. The old dam was 11 feet high, but when the state reservoir in the upper waters failed some 14 or 15 years ago, the structure was carried out, together with the adjacent buildings, and a large body of sand was washed off from the bank, leaving a wide shelving surface of rock exposed. There is a rapid in the river opposite, but the site does not appear to be a favorable one for a dam of much height. The privilege is said to be owned by Frederick Emerson, of Watertown.

Power at Watertown.—The section of river now to be described is far the most important and valuable in the whole course as regards water-power. The stream has here reached substantially its maximum volume, and in the $3\frac{1}{2}$ miles within the city limits falls over 120 feet,(*a*) measured from the top of the falls at the new pump-works to a

a In 1875 a survey was made of this section of Black river for the Watertown Manufacturers' Aid Association, and the fall within the city limits was reported as 111.75 feet. There is reason to believe, however, from measurements which were made with a pocket-level, that the fall between Diamond (or Dramand) island and the new pump-works may have been incorrectly determined, and the entire fall within the city may be estimated to be as much as 122 feet.

point about 5,500 feet below Taggart & Davis' dam. Watertown is admirably situated in the midst of a rich agricultural section, with deposits of the very best of iron-ore near at hand, with a ridge of limestone passing directly through the city and supplying a superior flux for the reduction of ore, with lumber easily to be obtained from the pine forests of Canada and the adjacent counties to the eastward in New York state, and with an abundance of brick and stone immediately accessible. The city itself is the most charming one in this portion of the state, and in 1880 had a population of about 10,700. It is distant 13 miles by rail from Sackett's Harbor, on lake Ontario, and has good facilities of communication with the principal cities of the United States and the coal-fields of Pennsylvania. The distances by railroad from a few prominent points are as follows:

Rail distances from Watertown.

Terminal points.	Distance.	Route.
	Miles.	
Watertown to New York	325	Via the Rome, Watertown, and Ogdensburg, and New York Central and Hudson River railroads.
Do	330	Via the Utica and Black River, and New York Central and Hudson River railroads.
Watertown to Albany	182	Via the Rome, Watertown, and Ogdensburg, and New York Central and Hudson River railroads.
Do	187	Via the Utica and Black River, and New York Central and Hudson River railroads.
Watertown to Buffalo	225	Via the Rome, Watertown, and Ogdensburg railroad to Charlotte, and thence through Rochester by the New York Central and Hudson River railroad.
Do	244	Via the Rome, Watertown, and Ogdensburg railroad to Syracuse, and thence by the New York Central and Hudson River railroad.
Watertown to Scranton, Pennsylvania	234	Via the Rome, Watertown, and Ogdensburg railroad to Rome, and thence by the Delaware, Lackawanna, and Western railroad.
Do	236	Via the Rome, Watertown, and Ogdensburg railroad to Syracuse; thence to Binghamton by the Syracuse, Binghamton, and New York railroad, and thence to Scranton by the Delaware, Lackawanna, and Western railroad.
Do	248	Via the Utica and Black River, and Delaware, Lackawanna, and Western railroads.

The leading manufactures of the city by water-power are of paper and pulp, spring-wagons, buggies, sewing-machines, force-pumps, vacuum-brakes, steam-engines, and general machinery; water is also pumped for the city supply by power from the river. There are 5 flouring- and grist-mills, one pearl-barley mill, several tanneries, mostly of small size, two small woolen-mills, in addition to which moderate powers are utilized for the manufacture of lamps, furniture, locks, sashes, doors, blinds, cabinet-ware, boots and shoes, and bakers' goods. The first use of the river for power at this point is said to have been made in the year 1802, when a grist-mill was built opposite Beebee's island. In 1808 the manufacture of paper was introduced, and in 1814 that of cotton and woolen goods. Although it is claimed that wool is easily obtained, that the water of Black river is particularly well adapted to cleansing it, and that from Memphis and other shipping points, via Chicago and the great lakes, "cotton can be landed cheaper in Watertown than it can be in New York city",(*a*) yet enterprises for the manufacture of goods from those materials have hitherto been unfortunate here, no less than seven having been initiated between the years 1814 and 1836, of which none probably have now any existence, and the only present representatives of those branches of industry are two small woolen-yarn mills, with two sets of machinery each. Considering the natural resources and demands of the surrounding region and the opportunities for reaching more distant markets, the location of the city would seem especially suited to the manufacture of pulp and paper, and the more finished articles in wood, leather, and iron—such, for instance, as agricultural and dairying implements, boots and shoes, and machinery.

The 122 feet, more or less, of fall occurring within the limits of Watertown is naturally separated into a number of successive privileges, as follows:

1. Immediately above the upper boundary of the city a large island, which for convenience may be called the Water-works island, divides the river into two branches, which again unite from nearly opposite directions upon the boundary, at the head of a natural barrier of rock which now opposes the passage of the stream and causes abrupt falls of about 14 feet, increased within a short distance by rapids to 16 feet. Above this locality the left bank is low and flat, and a dam at the head of the falls would submerge a considerable tract of good meadow-land; but the privilege has been easily and simply improved by blasting a race-way through the rock on the south shore from the top of the falls to the pump-house, thereby commanding an ample supply of water for the power needed. A heavy masonry bulkhead and wing-walls guard off freshets and ice. Two duplex double-acting plunger-pumps, 18 by 36 inches in size, are run at a speed of 20 revolutions per minute, lifting water 175 feet to a distributing reservoir There are also pumps on each of the lower island privileges, supplying the same reservoir. At the privilege being described two water-wheels, 6 feet 2 inches in diameter, manufactured by R. D. Wood & Co., of Philadelphia, are run under a head of 16 feet. There is at all times a large surplus power at these falls, which probably could be utilized to the best advantage by running a branch race or flume from the present one to some point below the pump-house. The cutting of an independent race, or an extension of the present one, would be through rock, and on that account expensive. There is no other building than the pump-house in the vicinity, on either bank, so that abundance of building-room remains.

a Attractions and Commercial Advantages of Watertown, by Hon. Charles R. Skinner (1876).

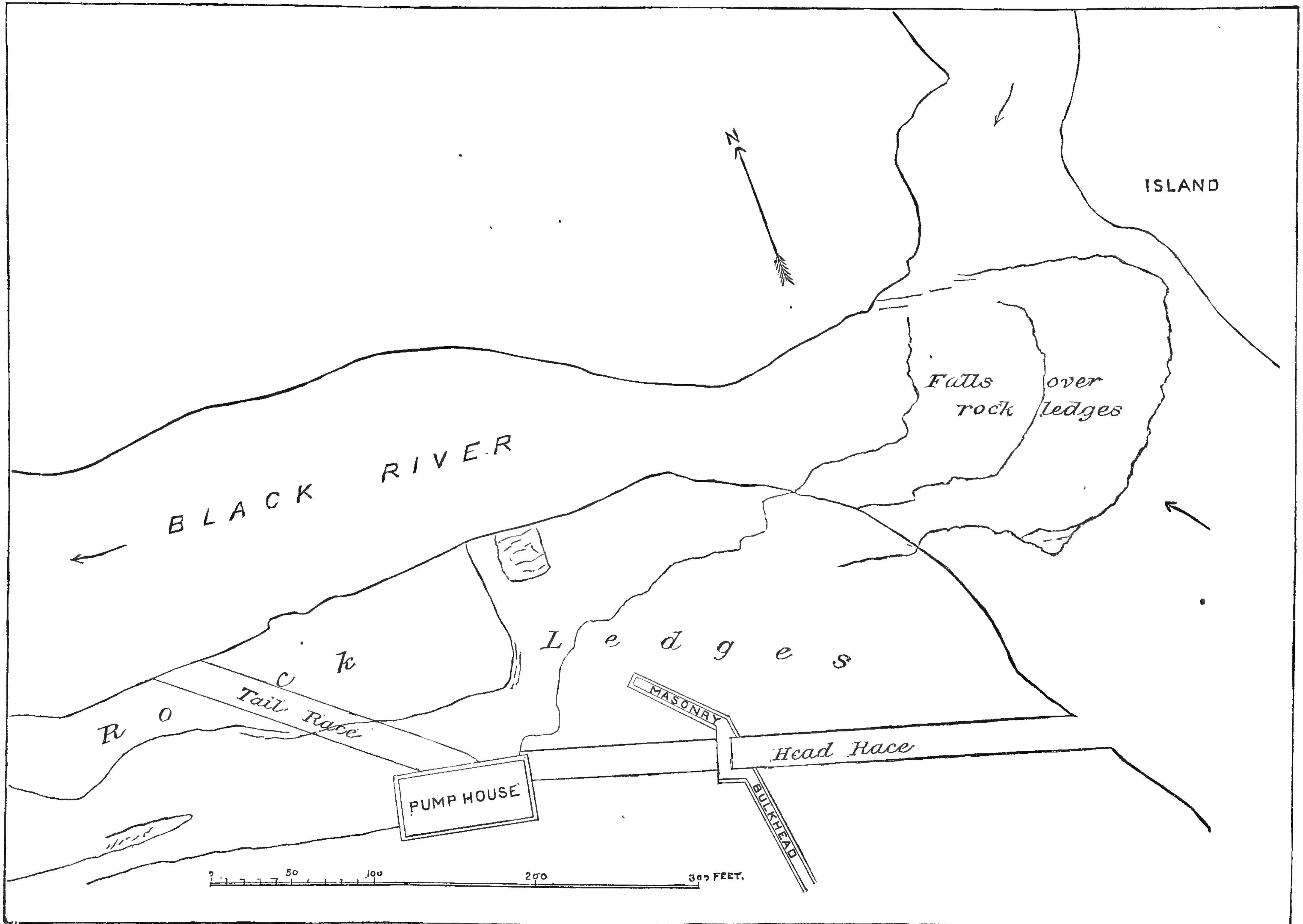

FIG. 2.—Plan of Water-privilege at city pump-works, near Watertown.

2. From the above privilege to the head of Diamond (or Dramand) island, a distance of 2,500 feet, there is a fall which is probably not far from 12 feet, increased by 2 feet in the succeeding 2,000 feet to the crest of the upper dam at Sewall's island, or say a total of 12 or 14 feet, entirely unemployed. Below the water-works falls and rapids there begins a stretch of smooth water, succeeded by a descent of about 6 feet in 600 or 800 feet as indicated by pocket-level. There is then a short interval of rapid water, and below it follow an abrupt pitch and rapids, together covering another fall of 6 feet in 600 or 800, and extending nearly to slack-water. Here, as indeed along the entire course of the river through Watertown, the bed and banks are of solid limestone rock, the latter in this vicinity 10 or 15 feet high above low water. The power above Diamond island could very easily be developed by a dam at the main fall near the head of the island, or by a dam in two sections running out from either shore to the island itself. The banks are of good height there, suitable for building, but not yet built upon at all.

3. Eleven hundred feet below the foot of Diamond island is Sewall's island, which again gives rise to two channels; from points near the head and foot of this island sections of dam have been thrown across to the adjacent banks, thus forming two falls opposite the island. From the crest of the upper dam to the crest of the lower, the fall as shown by the survey of 1875 is 15 feet.(*a*) Of the privilege on the north branch the Davis Sewing Machine Company owns one-fourth, the Sewall estate one-fourth, and the Remington Paper Company the balance above that belonging to four vacant lots on the north main bank which together control three-thirteenths of nine-tenths of the flow of the branch, estimated as equivalent to perhaps 100 effective horse-power. Of the privilege on the south branch, the Watertown Paper Company owns one-eighth and the Remington Paper Company the remainder.

On the north main bank of the river the only use of power is at the Remington Paper Company's pulp-mill, where a head of 13½ feet is obtained and 635 horse-power of wheels are run. A wooden flume 11 feet wide and 8 feet deep runs several hundred feet along the bank, past the vacant sites already referred to, on which are a couple of old wooden buildings once used for some kind of manufacturing, but now unoccupied, and one of them in ruins. On the island are the principal works of the Remington Paper Company, manfacturing news printing-paper, of which the production is about 9 tons per day. Including the pulp-mill on the main shore, about 1,000 horse-power of wheels are run, from which full capacity can be realized eight or nine months in the year. There are also the extensive works of the Davis Sewing Machine Company, which, in an article upon the manufactures of Watertown, published in 1876, was stated to employ 175 hands and to have manufactured, in 1875, $300,000 worth of machines; and also the Watertown Paper Company's mill, at which is made the same variety of paper as by the Remington company. The two sections of dam belonging to this privilege have a combined length of roll-way of from 350 to 400 feet, on which the extreme freshet-rise amounts to about 9 feet. Backwater sometimes causes a stoppage of the Remington mills, and also, it is presumed, of the other works, for as much as a week.

4. At the lower privilege at Sewall's island the fall from the crest of the dam to the foot of the island is 13 feet, increasing to 19 feet at the crest of the dam at Beebee's island. The fall actually utilized, however, at the mills does not exceed 12 or 14 feet. The property on the north main bank is owned by the Watertown Spring Wagon Company, but no power is used there and the ground is vacant. On the island side of the adjacent channel a short timber flume conveys water to the large works of the Bagley & Sewall Company, where 150 horse-power of wheels are run under a head of 12 feet. This company has a foundery, and manufactures general iron-work and machinery, and especially force-pumps; it employs 125 hands, and turns out 2,500 tons of cast-iron work yearly. The principal use of power from the lower falls at Sewall's island is from the south channel, on the adjacent main bank, where a long timber flume supplies a number of mills and factories, two or three of which are of very important size. The most prominent among these are the Watertown Spring Wagon Company's works, enjoying a first right to sufficient water for 5,000 spindle-power, and actually using a fall of 14 feet, and 200 horse-power. The business is very extensive, and is conducted in a main building 283 by 55 feet in plan, and a new building 100 by 112 feet, both four stories high. In 1881 this company shipped 4,000 wagons. Power is transferred from the wheel to the main factory by a shaft 175 feet long.

Next in importance is the factory of the H. H. Babcock Buggy Company, using a fall of 12 feet, and probably 125 horse-power. The main building is 250 by 40 feet in size. One hundred hands are employed, and in November, 1882, 8 or 10 buggies were being manufactured per day, the establishment having a capacity for turning out 20 in that time. Farwell & Rhimes' flouring-mill has 3 runs of stone and 10 sets of rollers, with a capacity for grinding a car-load of corn and 150 barrels of flour daily. Besides these larger concerns power is also employed by a 2-run pearl-barley mill and a bakery. Three small tanneries and a wood-working shop were also observed, but they appeared to be doing but little work. With the present mode of development the power on this channel is all utilized, and there is little or no opportunity to obtain reliable power for further manufacturing. In some years there is sufficient water throughout, while in others a scarcity exists for one, and even two months. The flume, ordinarily containing 8 or 10 feet depth of water, is sometimes drawn down by the mills so that toward the foot it does not contain more than 2 feet.

5–6. At Beebee's island, which is 2,300 feet below Sewall's, there are grouped a large number of manufacturing concerns of varying size and importance. Here, as above, there are two channels, separated by the island, and

a The Remington company states its fall as 17 feet, possibly gained by the use of brackets on the dam.

the stream is confined within a gorge, with vertical rocky sides. Ledges of rock in the north or main channel form natural falls, at the head of which is a timber dam not over 10 feet high at the highest point, and running out thence on the rocks of the island with a height of only a foot or two for nearly half its length. At the suspension bridge just below the falls this channel has a low-water width of about 90 feet, and a high-water width of probably 135 feet. From the crest of the dam to slack-water a little below the island the descent is 35 feet, which in the north channel is at present uninterrupted by a second dam, but in the south channel is by that means divided into an upper fall of 20 feet, and a lower of 15 feet.

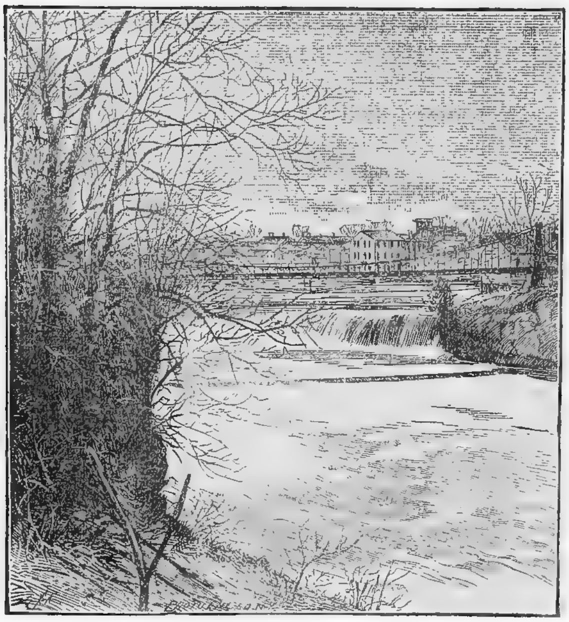

FIG. 3.—Falls at Beebee's island.

On the north main bank water is conveyed three or four hundred feet from the dam, a short distance in a rock cut, and the remainder of the way in a timber flume 8 or 10 feet wide and 5 or 6 feet deep. The principal concerns using power are the Watertown Steam Engine Company, manufacturer of portable and stationary engines, employing a fall of 18 feet and a 100 horse-power wheel from which the power is transferred by a shaft 200 feet long; the Watertown woolen-mills, running 2 sets of machinery on yarns, and Allingham & Co., employing 25 hands in the manufacture of boots and shoes. There is also a 4-run grist-mill, a sash-, door-, and blind-shop, a small furniture-shop, and a small file-shop. With the single exception noted, the falls in use range from 8 to 14 feet with full flume. No other power is used from this channel, but the right is owned by certain parties to build another dam and use the remainder of the fall (presumably 15 feet) as is done in the south channel. It is a valuable privilege, being in the business part of the city and but 1,000 feet from the public square.

On the south side of the island there is at the head of the falls a heavy masonry bulkhead and wall, shutting off from the channel and flume below all water except that allowed to pass through the gates. This wall is about 275 feet long, 6 feet wide on top, and rises 12 feet above the water in the pond, opposing an effectual barrier to freshets and ice. Water is admitted through six gates, each opening about 5 feet wide in the clear, into a timber flume having at the bulkhead a width of about 45 feet and a depth of 8 feet. Power is utilized on the south main bank by Knowlton Brothers, manufacturers of glazed medium papers, production 3 tons per day, and employing at least 300 horse-power of wheels under heads ranging from 11 to 15 feet; at I. A. Graves & Co.'s flouring-mill, having 5 runs of stone, a full line of rollers, and using a fall of 16 feet, with about 250 horse-power of wheels; by the Hitchcock Lamp Company, employing 60 hands; and by several other establishments of small size, comprising a cabinet-shop, a machine-shop, a sash-, door-, and blind-shop, and a shop for filing saws. On the island side of this upper fall there is an old ax factory, now unoccupied; G. Lord's foundery and machine-shop and manufactory of agricultural implements, using 12 feet of fall and employing 15 or 20 hands; a sash-, door-, and blind-shop, and a city water-works pump.

The tail-water from these various mills is discharged into the south channel, along which they are located, and which is mainly taken up with the head-race or flume, and passing under the latter is collected in a small basin constituting a second level and formed by a second dam. There are rapids below the dam, and the mills are not placed so as thoroughly to utilize the fall. From this level are supplied the Eames Vacuum Brake Company, having two 100 horse-power wheels working under a head of 12 feet, and one wheel of 50 horse-power under a head of 26 feet, combining both falls; also a furniture factory, a 6-run flouring- and grist-mill, and a planing-mill.

7. Three thousand feet below Beebee's island, but yet within the city limits, there is still another power in use. The dam is a crib-work structure with rollway 280 feet long, and is 14 feet high. The timbers are 6 by 10 inches in cross-section and the back-slope is 30 feet long. The dam was built in 1879, at a cost stated to have been $3,000. Wooden flumes extend down each bank from the dam, and supply, on the north side, the mill of Taggart Brothers, manufacturers of news-paper and of flour-bags. Poplar and spruce are here ground for wood-pulp, while rope is used for bagging-material. The works have a capacity of 5 tons of finished product per day, use about 800 horse-power, and give employment to 50 men. On the opposite bank of the river there are a 3-run flouring- and grist-mill, J. S. Robinson's 2-set yarn-mill, and A. M. Farwell's tannery. Probably these three concerns do not together use more than 120 horse-power, leaving a large amount unemployed, for which there is suitable and abundant building-room. The fall on this privilege is stated to be 14 feet, which, according to Hinds' survey, covers the descent from the crest of the dam to the railroad bridge, 1,200 feet below.

8. From the railroad bridge to the lower boundary of the city, 4,300 feet down stream, there is a further fall of $8\frac{3}{4}$ feet, entirely unimproved.

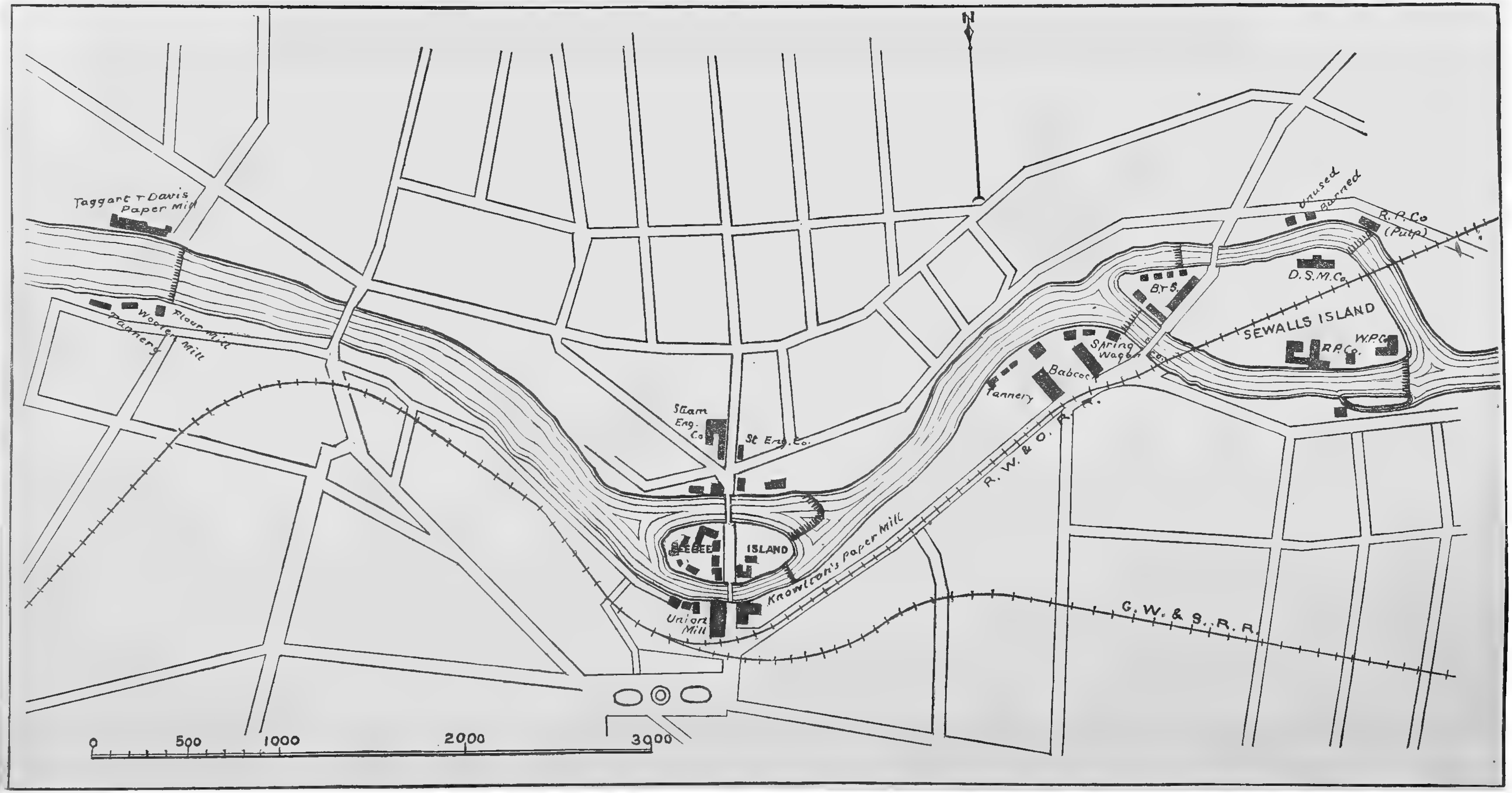

FIG. 4.—Plan showing location of dams at Watertown.

Each fall or section of the river, in its course through Watertown, has now been described. It is impossible to say just how much power still remains unemployed and available for manufacturing, or how much would be available if the mills now running were all supplied with the best machinery and with economical wheels; if they were so located as to employ all the water at each privilege under the full head, instead of under various lesser falls as is now the case; and if the water were used without leakage at dams, in flumes, and in pen-stocks. An estimate will be presented, however, of the total power of the river here, accompanied by a statement, based on the returns of the census enumerators, of the power of wheels in use, from which some idea can perhaps be formed of the amount still idle. To recapitulate, it may be said, in brief, that at the Water-works privilege there is a fall of 16 feet and an important amount of surplus power; that thence to Diamond island there is say 12 feet of fall entirely unimproved; opposite the upper end of Sewall's island a fall of from 15 to 17 feet, the power of which is thoroughly utilized in low stages of river, although on the north main bank there are several vacant sites, together entitled to about 20 per cent. of the flow in the adjacent channel; opposite the lower end of Sewall's island an immediate fall of 12 or 14 feet, increasing to 19 feet beyond, though only the first-mentioned amount is actually employed (at this privilege the power in the south channel is thoroughly utilized, but there is a considerable surplus in the north channel, probably several hundred effective horse-power); opposite Beebee's island a descent of about 35 feet, in two falls, with 15 feet of this in the north channel unimproved and constituting a very valuable privilege; 3,000 feet down stream a fall of 14 feet, largely improved, but still offering surplus power on the south bank; and thence to the western boundary of the city an unimproved fall of 8¾ feet.

The undeveloped falls are sufficient in themselves to warrant a large increase in the already extensive manufacturing of this flourishing city, but at the older and more thoroughly utilized privileges, such as those at Beebee's island and opposite the foot of Sewall's island, the rights to water are in a peculiar and very unattractive position. The occupancy of these privileges dates far back in the century, and by the original owners rights were deeded in the most vague and indefinite manner possible. It was assumed that the power of Black river was equal to all demands, and almost no limitations were placed in the deeds conveying it. Thus, on the south upper level at Beebee's island, power was granted "sufficient for a machine-shop", "sufficient for a cast-iron business", and so on. The deed to the Knowltons, paper manufacturers, was so comprehensive that according to a literal reading they could claim the entire flow of the river. By the deeds the various grantees were holden for certain proportions of the dam, as regards expense of maintenance, and this was carried so far that at length it was found that they were together responsible for *four-thirds* of a dam. By mutual concessions serious disputes have been avoided, but it is plain that the claims to water exist here on a very unsatisfactory basis.

Again, at the south lower privilege opposite Sewall's island, occupied by the Watertown Spring Wagon Company and other concerns, the Black River Cotton & Woolen Manufacturing Company first obtained control of the power, and afterward deeded or leased portions to different manufacturers, reserving 5,000 spindle-power, which later came into the possession of the spring-wagon company. The Black River company leased to one party water "sufficient to carry a paper-mill", and in another case "sufficient for a machine-shop and the necessary appendages of the same". V. P. Kimball has water for 3 runs of stone, or their equivalent, provided that sufficient should thereby be left for the cotton factory and any previous grants, subject to payment, if demanded, of one pepper-corn every July 11 to the party of the first part. He is holden, to a certain extent, for expenses of repairs. In one instance sufficient water was granted for a bark-mill and all necessary appendages of a tan-yard; in another, sufficient to carry four carding-machines, provided that enough should always be left for the cotton factory, paper-mill, and all other establishments previously given rights to the water.

Estimate of power at Watertown.

Stage of river.	Natural drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. Per foot fall.	Water-works privilege—only partly utilized.	Below water-works to head of Diamond island—not used.	Upper end of Sewall's island—mainly in use.	From crest of lower dam at Sewall's island to crest of Beebee's Island dam—12 or 14 feet partly utilized.	Upper fall at Beebee's island—largely in use.	Lower fall at Beebee's island—unimproved in north channel.	At Taggart's mill—surplus power on south bank.	From lower railroad bridge to lower city line—not used.	Total within city limits.	Total effective horse-power of wheels in use.
	Sq. miles.	*Cubic ft.*		*16 ft. fall.*	*12 ft. fall.*	*17 ft. fall.*	*19 ft. fall.*	*20 ft. fall.*	*15 ft. fall.*	*14 ft. fall.*	*8¾ ft. fall.*	*122 ft. fall.*	
Low water, dry year	*a* 1, 816	1, 050	119. 28	1, 910	1, 430	2, 030	2, 270	2, 390	1, 790	1, 670	1, 040	14, 550	4, 675 ±
Low water, average year		1, 300	147. 68	2, 360	1, 770	2, 510	2, 810	2, 950	2, 220	2, 070	1, 290	18, 020	
Available 10 months, average year.		1, 400	159. 04	2, 540	1, 910	2, 700	3, 020	3, 180	2, 390	2, 230	1, 390	19, 400	

a Effective drainage area in dry season, 1,541 square miles (see page 5).

NOTE.—Rainfall on basin approximately estimated at 9 inches in spring, 10 in summer, 12 in autumn, 8 in winter, and 39 for the year; there are no data, however for accurate determination.

The river below Watertown.—Passing below Watertown, the river presents numerous opportunities for the development of large powers. The surrounding country is level or very slightly hilly, and the river-banks themselves are generally succeeded at once by level ground, underlaid by limestone and admirably suited to building. The rock is seamy, and might not hold water well in races unless calked in some way; but timber flumes, the almost invariable mode of conveying water at privileges on this river, are always practicable. The stream is quite narrow in this section, and rushes along with rapid fall. Below the city the banks are for a while gentle in rise, and are at times smooth sloping ledges of limestone. Farther down they continue of solid rock, but rise abruptly from the water from 15 to 25 feet. Much of the way the upper layers have been broken off in immense fragments, which still lie in place or tilted, while the lower strata remain firm. Below the smooth sloping banks mentioned there was noticed in particular, and determined roughly by hand-level, a descent of from 3 to 5 feet in 800 feet; then a continuous rapid fall for perhaps a quarter of a mile, amounting to 14 feet, including and terminating in a sudden pitch of about 4 feet; then a continuous rapid, with a fall of about 7 feet in 800; then a fall of 5 feet in about 400, succeeded by slack-water from a dam half a mile below and probably not over 2 miles from Watertown.

The privilege next to be described has recently been developed and is a very fine one. It extends an eighth of a mile below the present mill, and embraces a total fall of probably 45 or 50 feet, of which 30 feet is actually in use. It is owned and employed by C. R. Remington for the manufacture of news-paper from wood-pulp, the works having a capacity of 4 tons per day. The dam extends from the bulkhead 300 feet in a straight piece up stream parallel to the adjacent bank, and then curves around toward the opposite shore with an additional length of 350 feet, making a total overfall of 650 feet. It is built of 6 by 10 inch timbers, those running with the stream inclined, and has a back slope of 3 base to 1 vertical. The height ranges, according to the contour of rock beneath, from 4½ to 6¾ feet, and gives therefore an extreme width at base of about 20 feet. The bottom timbers are pinned with 1⅛-inch pins to bed-rock. The abutment at the north end rises 5½ or 6 feet above the crest, and is considered high enough for all ordinary freshets. In the spring of 1882 the river is said to have been about as high as it often is, and rose 3 feet on the dam. The face of the structure is vertical, and 1 inch back from the crest, on the up-stream slope, a strip of ½-inch iron, 1 foot wide, runs the length of the dam, and guards against damage to the timber-work from floating ice or other material.

The bulkhead is built of masonry, with two 15-foot arches for the gate-ways. It has a length, measured to the extreme ends of the wall, of 110 feet, a width on top of 5 feet, and a batter of 5 inches to the foot. Water is admitted through the bulkhead by means of ten gates, 6 feet deep and 3 feet wide, pivoted in the center at top and bottom. From the bulkhead water is brought about 200 feet to the wheels in a race having an inside width of 30 feet and inclosed on the river side by a wall 3 feet wide on top and battering about 4 inches to a foot. It is received in a timber fore-bay about 33 by 70 feet in size, and runs one 25-inch and six 30-inch Curtis (Ogdensburg) wheels. These are arranged in pairs on a horizontal shaft, which is about on the level of the bottom of the race and extends into the mill as the main shaft, without intermediate gearing. The wheels are provided with draught tubes, run under a head of 30 feet, and have a combined rating of about 900 horse-power. At the time this privilege was visited, in the latter part of November, 1882, the mill had been in operation only about six months, but during the summer the stream had been very low; yet, as has previously been stated, at the lowest stage then observed, with the wheels running at full capacity, there was a wastage of 6 inches of water on the dam. The banks are very rocky at this point, and 1,500 cubic yards of rock had to be blasted out for the tail-race. The main mill is 42 by 106 feet in size, the machine-room 32 by 120 feet, and the boiler-house 30 by 42 feet.

Below the Remington works the gorge deepens, the river is in places less than 50 feet wide, and much of the way is hemmed in by walls of solid rock from 30 to 50 feet high. The descent is very rapid, and is varied now and then by heavy pitches. Thus by hand-level one fall of 10 or 12 feet in 500 feet was measured, and there were other falls equally great or greater both above and below. The river finally enters a still deeper part of the gorge, where the fall is very heavy and the precipitous banks rise 50 or 75 feet high, and there then succeeds a long stretch of smooth swift water. The surrounding country is very level, and the channel of the stream has been cut down into it.

At Brownville, 3½ or 4 miles by road below Watertown, is met the next improved power. The stream is here controlled by a log dam about 100 feet long and 17 or 18 feet high. This is a rough-appearing structure, and is very leaky, as are also the flumes which run from it down each bank. The longer of these is on the right bank, and is probably 800 or 1,000 feet in length. The half of the privilege on the south bank is owned by George Frasier, and is used in part for a 6-run flouring- and grist-mill having a fall of 17 feet, and occasionally in part for a saw-mill. On the north side of the river the mill-owners are associated in the Brownville Dam Company for the purpose of keeping up the dam. The Brownville Yarn Company owns one-quarter of the privilege on that bank, and the mill in which its operations are carried on has been there for over fifty years. It has manufactured cotton-yarns, the mill containing 3,000 spindles, but the works were not running when visited, though expected to start soon. A head of 16 feet is obtained at this mill, which is the first below the dam, and a 137 horse-power wheel is run. There is so much waste on the privilege by leakage and otherwise that it is thought that no more mills could be run, with a certainty of permanent power, than are now accommodated. Besides the cotton factory there are on

that side of the stream Webb's cabinet-shop, employing 4 or 5 hands and using a 60 horse-power wheel; Sluman's flouring- and grist-mill, with 4 runs of stone and using 14 or 15 feet of fall; a good brick foundery, not in operation; and a straw-board paper-mill, which was found to be shut down for the winter.

The cotton factory has a preferred privilege here. The other concerns have rights to surplus water, though the actual amounts are not very definitely specified. Although with economical use of the water much more manufacturing might be sustained, the location as now improved is not an attractive one, and it is said that in some cases the accumulated taxes on unoccupied sites are probably greater than the latter would sell for if unincumbered. Opposite Brownville the river-banks are less steep than generally on this part of the river, but below the mills the gorge, shut in by vertical walls, which has been noticed at Watertown and below, again appears. As naturally might be expected, the rises in such a confined channel are at times very great. Thus at the time of the failure of the state reservoir the water is said to have risen 21 or 22 feet on the crest of the Brownville dam, and in the river below to a height of 5 feet above the tops of the flumes. At times floating ice chokes up the narrow gorge below the mills and causes backwater to rise nearly to the point of submerging the flumes.

The last power on the river is at the little village of Dexter, about 3 miles below Brownville and less than a mile from the head of Black River bay. The ravine which hitherto has shut in the stream now opens out, and though limestone still appears in the banks these are low, and the dam sets back the water over a large extent of land. Navigation for boats of 5½ or 6 feet draught continues up to this point, and considerable lumber is brought here by that means. Two islands in the river form with each other and the adjoining shores three channels, each of which is closed by a section of dam. These sections are built of logs, and are old and extremely rough in appearance. The fall obtained is 10 or 11 feet. A number of concerns are supplied with power, some by races and some by wooden flumes, but none of them are of large size, and there is nearly always water going to waste on the dam. There are two sash-and-blind factories, together employing some 35 hands in the summer season and using yearly from 1,000,000 to 1,500,000 feet of lumber; two flouring- and grist-mills, with 3 runs of stone each; and a small saw-mill. From the pool above the dam a canal leads off across the village to a large and fine stone mill, which was formerly occupied for woolen manufacturing and gave employment to 300 hands. This mill is said to be owned by New York parties, and has been shut down for eight or ten years. With it is reported to be controlled two-thirds of the entire flow of the river at this privilege.

It will be evident, from what has been said, that Black river offers an unusually large amount of available water-power; and there can be little question that, with the advance of time, and the increase of wealth, population, and manufacturing interest in this section, the numerous fine privileges will be developed one after another, those now imperfectly utilized by comparatively unimportant mills being purchased and improved for larger enterprises, until the river shall become, as it is undoubtedly entitled to do, one of the most prominent of the eastern manufacturing streams. Taking the fall from the top of the Carthage dam to the surface of lake Ontario as 477 feet, and the mean volume for this fall, during low water of an ordinarily dry year, as 1,050 cubic feet per second, then the corresponding gross or theoretical power of the river will be represented by 56,900 horse-power, while the total rated effective or net horse-power of wheels in use amounts, for the section of river considered, to only about 7,800 horse-power. The following table presents a summary of the various privileges that have been mentioned. It is not supposed to show in detail all the available sites for power, but only the more prominent ones, such as were brought especially to attention:

Summary of the principal water-privileges on Black river.

Locality.	Natural drainage area. (a)	Fall.	Estimated theoretical horse-power. (b) Low water, dry year.	Low water, average year.	Available 10 months, average year.	Total rated effective horse-power of wheels in use.	Manufacture.	Remarks.
	Sq. miles.	*Feet.*						
From North Branch reservoir to crest of Forestport dam.	....	692	....	....	....	37	....	Distance by river, 21.6 miles.
From crest of Forestport dam to crest of Lyon's Falls dam.	....	327	....	....	....	121	....	Distance by river, 17 miles.
Lyon's Falls..........	807	64½	1,900	2,640	3,080	....	Privilege recently purchased with the design of developing in 1883 and erecting large manufacturing works.	Total fall about 69 feet, of which 64½ feet is to be developed. Surplus power for disposal.
From foot of Lyon's falls to crest of Carthage dam.	....	9½	....	....	....	....	....	Fall distributed over 42½ miles. Not available for power.
Carthage	1,741	55	6,250	7,810	8,440	1,120±	Machinery, iron, pumps, leather, flour, lumber, pulp, hosiery, and various articles in wood.	Fall occurs in 4,600 feet. Numerous opportunities for further use of power.

a The effective drainage area in the dry season is to be considered as 275 square miles less than the figures here given (see page 5).
b Based upon average flow for the twenty-four hours.

Summary of the principal water-privileges on Black river—Continued.

Locality.	Natural drainage area. (a)	Fall.	Estimated theoretical horse-power. Low water, dry year.	Low water, average year.	Available 10 months, average year.	Total rated effective horse-power of wheels in use.	Manufacture.	Remarks.
	Sq. miles.	*Feet.*						
Rawson's mill	1,750	16±	1,820	2,270	2,450	....	Power once used for saw- and shingle-mill, but dam carried out by ice about 1870.	Between Carthage and Madame De Feriet's bridge.
Great Bend	1,763	14	1,610	2,000	2,160	150–160	Hanging-paper	Production, 3 tons per day.
Felt's Mills	1,787	10±	1,170	1,450	1,570	125±	Power used in saw- and shingle-mill, grist-mill, ax-helve factory, and large tannery.	8,000 hides tanned yearly at Veber's tannery.
Black River	1,794	16	1,890	2,340	2,530	265±	Chairs and chair stock mainly; also flour, cabinet-ware, and shingles.	One firm turns out 20,000 chairs yearly.
Within three-quarters of a mile below Black River village.	1,795	45±	5,320	6,590	7,110	....	Fall unimproved	Three falls of say 15 feet each.
Huntingtonville	1,801	11±	1,300	1,610	1,740	....	Power formerly used in saw-mill, and in scythe and ax factory, but the works and dam were carried away when the state reservoir failed.	Say 2 miles from Watertown; not a desirable site for a dam.
Watertown	1,816	122	14,550	18,020	19 400	4,675±	Mainly paper, pulp, spring-wagons, buggies, sewing-machines, force-pumps, vacuum-brakes, steam-engines, and general machinery. There are 5 flouring- and grist-mills, 1 pearl-barley mill, several tanneries, 2 small woolen-mills, and also various other establishments for the manufacture of lamps, furniture, locks; sashes, doors, and blinds; cabinet-ware, boots and shoes, and baker's goods.	Large amount of unemployed power (see description).
Within 3,000 or 4,000 feet above slack-water from Remington's dam.	1,830	30±	3,610	4,460	4,840	....	Fall unimproved	Within say 2 miles of Watertown.
C. R. Remington's mill	1,830	50±	6,020	7,440	8,070	900	News-paper	30 feet of fall actually developed and in use. Production of mill, 4 tons per day.
Brownville	1,848	17±	2,070	2,550	2,780	300±	Flour, lumber, paper, cotton-yarns, cotton batting, and cabinet ware.	Cotton-mill has 3,000 spindles. Hydraulic works here are in poor condition.
Dexter	1,855	11	1,340	1,650	1,810	265+	Sashes and blinds, flour, and lumber.	Two sash- and blind-factories together employ about 35 hands in summer, and use from 1,000,000 to 1,500,000 feet of lumber yearly. Two-thirds of the entire privilege belongs with a fine woolen-mill, shut down a number of years ago.
Total from crest of Carthage dam to mouth of river.	1,741 to 1,855	477	56,900	70,440	75,860	7,800±	....	Not all practically available.

a The effective drainage area in the dry season is to be considered as 275 square miles less than the figures here given (see page 5).

THE MOOSE RIVER.

This important tributary of the Black river rises in western Hamilton county, within a few miles to the southwest and south from Raquette lake. It is made up by two principal branches, the more northerly of which receives the drainage from the Fulton chain of lakes. From the junction of these branches the course is westerly, until the stream unites with the main Black river just above the state dam at the head of Lyon's falls. The course of Moose river, even to the mouth, lies through an extremely rugged valley. There is considerable logging about the upper waters, and it is estimated that an average of 7,000,000 or 8,000,000 feet of timber, mainly hemlock and spruce, is annually floated down the stream. In the 30½ miles from the first lake of the Fulton chain to the mouth of the river there is a descent of 882 feet, or an average of very nearly 29 feet per mile. The drainage basin includes approximately 349 square miles.

The Lyon's Falls dam causes slack-water for a mile, more or less, up Moose river, and then occur natural falls almost as abrupt and easy to improve as those on the Black river below the above-mentioned dam. At the head of these an island forms two channels, across the northern of which is a low log dam; the dam across the south channel is not more than 80 or 100 feet long, and consists of loose stone piled up on the ledges, with a plank facing. The descent from the crest of the dam to the foot of the falls was found by hand-level to be about 45 feet. The power is utilized in Gould's large saw- and pulp-mill.

Not over a quarter of a mile above Gould's mill there is a fine privilege occupied by the Herkimer Paper Company for the manufacture of wood-pulp, and embracing a total fall of 33 or 34 feet. The stream is controlled

by a log dam, curving in plan, and water is conveyed a short distance to the mill, part way in a race inclosed by a river-wall of stone, and part way in a wooden flume. The head employed is 27 feet, under which are run 6 wheels of 180 horse-power each, geared in pairs to 3 shafts. For six or eight months in the year 720 horse-power can be realized, and in the lowest stage of river about 360 horse-power. The dam is tight, the wheels are of good pattern, and the power is economically utilized. At the head of the mill-pond there is another sudden fall of about 39 feet, also owned by the Herkimer Paper Company.

Some 3 or 4 miles farther up stream there are two more developed powers. The lower is occupied by Shon's paper-mill, and includes about 27 feet of fall, though the amount of fall or power actually in use was not ascertained. Above this privilege there is a pitch of 8 or 10 feet, and another of 2 or 3 feet, before reaching a fall of 34 feet partially utilized by Joel W. Ager in a small mill for the manufacture of rag wrapping and straw papers.

The Moose river is subject to heavy freshets, and for about two weeks in the year the Herkimer paper-mill is troubled by anchor-ice, though never sufficiently to cause a stoppage of work. Examination of the stream was confined to a few miles of its course above the mouth, including, however, the most important improved powers, and was made November 25, 1882; at that time the Herkimer company's, Gould's, and Shon's mills were all using the entire flow, excepting leakage, which was large at the two last-mentioned points.

Table of utilized power on the Black river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Black river	Lake Ontario	New York	Oneida	Saw	2	30	37	....	Remsen.
Do	do	do	do	do	1	12	21	....	Forestport.
Do	do	do	do	Flouring and grist	1		15	....	
Do	do	do	do	Furniture	1	8–9	10	....	Hawkinsville.
Do	do	do	do	Flouring and grist	1		50	....	
Do	do	do	do	Tannery	1	16	25	25	
Do	do	do	Lewis	Agricultural implements	1	Total fall utilized, though by no means to its full capacity, in Lewis county, about 230 feet.	30	....	
Do	do	do	do	Blacksmithing	1		15	....	
Do	do	do	do	Boots and shoes	1		....	....	
Do	do	do	do	Bread, crackers, etc	1		25	....	
Do	do	do	do	Carriages and wagons, and materials.	2		325	....	
Do	do	do	do	Cotton	1		137	....	
Do	do	do	do	File-shop	1		....	....	
Do	do	do	do	Flouring and grist	16		1, 439	....	
Do	do	do	do	Furniture	8		312	....	
Do	do	do	do	Hosiery	1		40	....	
Do	do	do	do	Iron-works	1		....	....	
Do	do	do	do	Lamps and reflectors	1		30	....	
Do	do	do	do	Lumber, planed	2		20+	....	
Do	do	do	do	Machinery	5		428	30	
Do	do	do	do	Paper (including wood-pulp).	8		3, 557	....	About 2,300 horse-power of this is used in Watertown.
Do	do	do	do	Piano materials	1		....	....	
Do	do	do	do	Sashes, doors, and blinds	7		280	....	
Do	do	do	do	Saw	6		100	....	
Do	do	do	do	Sewing-machines and materials.	1		[illegible]	....	
Do	do	do	do	Shingles	1		....	....	
Do	do	do	do	Tanneries	8		500	....	
Do	do	do	do	Vacuum brakes	1		250	....	
Do	do	do	do	Water-works supplied	1		....	....	
Do	do	do	do	Wheelwrighting	1		15	....	
Do	do	do	do	Wood turning and carving	3		40+	....	
Do	do	do	do	Wooden handles	1		....	....	
Do	do	do	do	Wooden ware	2		145	....	
Do	do	do	do	Woolen	2		30	....	
Do	do	do	do	Wool-carding shop	1		....	....	
Moose river and tributaries.	Black river	do	do	Furniture	2	22	14	....	
Do	do	do	do	Paper	3	59	1, 150+	....	
Do	do	do	do	Saw	4	57	370	....	
Do	do	do	do	Tannery	1	14	60	100	
Independence creek and tributaries.	do	do	do	Saw	9	136	400	....	
Beaver river and tributaries.	do	do	do	Flouring and grist	3	39	125	....	
Do	do	do	do	Saw	6	68	370	....	

Table of utilized power on the Black river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Beaver river and tributaries.	Black river	New York	Lewis	Tanneries	3	29	115		
Deer river and tributaries.	...do	...do	...do	Agricultural implements	2	20	34		
Do	...do	...do	...do	Blacksmithing	1	8	8		
Do	...do	...do	...do	Cooperage	2	26	30	12	
Do	...do	...do	...do	Flouring and grist	2	45	160		
Do	...do	...do	...do	Furniture	1	16	10		
Do	...do	...do	...do	Sashes, doors, and blinds	1	8	10	12	
Do	...do	...do	...do	Saw	12	132	292		
Do	...do	...do	...do	Tannery	1	14	8	8	
Sundry tributaries.	...do	...do	...do	Flouring and grist	10	229	380	40	
Do	...do	...do	...do	Sashes, doors, and blinds	2	58	26	25	
Do	...do	...do	...do	Saw	27	426	753		
Do	...do	...do	...do	Tanneries	2	13+	130	80	
Do	...do	...do	...do	Wheelwrighting	1	9	15		
Do	...do	...do	...do	Wooden packing-boxes	1	10	30		
Do	...do	...do	...do	Woolen	2	9+	12		
Do	...do	...do	Jefferson	Flouring and grist	1	28	36		
Do	...do	...do	...do	Furniture	1	14	10		
Do	...do	...do	...do	Saw	1	20	18		
Do	...do	...do	Oneida	Flouring and grist	1	28	30	25	
Do	...do	...do	...do	Saw	11	146	358		
Do	...do	...do	...do	Tanneries	3	42	90	20	
Do	...do	...do	...do	Wooden ware	1	7	8		
Do	...do	...do	Herkimer	Saw	2	20	18		

II.—THE OSWEGO RIVER AND TRIBUTARIES.

Drainage areas.

	Square miles.
Seneca river	3,447
Oneida river	1,421
Oswego river below junction of Seneca and Oneida rivers	4,868
Oswego river at mouth	5,013

THE OSWEGO RIVER.

A large part of western central New York is drained by this important river and its tributaries. The main stream is formed some 12 miles northwest of Syracuse by the union of the Seneca and Oneida rivers, whence its course is northwesterly to Oswego, where it empties into lake Ontario. The length by river from the junction at Three-River Point to the mouth is about 20½ miles. The drainage basin along this interval embraces only a narrow strip of country, level or moderately rolling; but above the junction of the Seneca and Oneida rivers it spreads out, attaining an extreme width to the east and west of about 100 miles, and to the north and south of between 70 and 80 miles. From the low and level lands which border lake Ontario there is a gradual rise, south of the Seneca river, to north-and-south ridges, which separate the various lakes of that region, and extending farther south become merged in the still more elevated country lying along the southern water-shed of lake Ontario.

The country naturally tributary to the Oswego river is one of splendid resources, is quite thickly settled, contains important cities and many flourishing villages, and is threaded by a network of water and railroad transportation routes. In common with the northern part of the United States generally, it is more or less overlaid by drift materials—sand, gravel, clay, and bowlders; but the decomposition of native rocks has produced an unusually rich, productive soil, yielding largely in the various grains, and also finely suited to dairying, wool-growing, and stock-raising. There is an abundance of the best of building-stone; gypsum, and rock for both quick-lime and water-lime, are extensively quarried, and in Onondaga county are the valuable salt springs so largely utilized in the vicinity of Syracuse.

Perhaps the most striking feature of the district under consideration is its remarkable collection of beautiful lakes, adding greatly to the attractiveness of this part of the state, and of especial importance to navigation and manufacturing interests. Proceeding from west to east, the principal lakes are, in order, Canandaigua, Keuka or

Crooked, Seneca, Cayuga, Owasco, Skaneateles, and Oneida. These seven include a water-surface of, approximately, 280 square miles, increased by the four lesser lakes, Cross, Onondaga, Otisco, and Cazenovia, to about 295 square miles. The larger of these, Oneida, Cayuga, and Seneca, are utilized for steam-towing navigation, having water connection with the Erie and Oswego canals. More or less freight is transported over Keuka and Canandaigua lakes in steamers, while Owasco, Skaneateles, Otisco, and Cazenovia are controlled by state dams and act as feeders to the Erie canal. On glancing at a map of this region the eye is at once struck by the peculiar shape and position of nearly all these lakes. With the single noteworthy exception of Oneida, they are long and narrow and have a general north-and-south direction; or, more accurately, they are spread out like rays, their courses, if extended, intersecting from 40 to 60 miles northward, in lake Ontario, or in Prince Edward county on its northern shore.

Cayuga and Seneca lakes are particularly noticeable for their depth and for the abrupt slopes of their beds. The correspondence of the rock strata on opposite shores, and other facts, indicate that the depressions were hollowed out by some very powerful action of nature. In a paper upon the geological history of these two lakes,(a) Dr. Charles W. Foote elaborates the view that they first occupied depressions previously eroded by the action of an inland sea which extended to the northward, and formed into basins as the land gradually rose; and that these basins were subsequently scooped out and much deepened by glaciers moving southerly. There is also much evidence to show that at some period they had their outlets toward the south, to the Susquehanna, but by the removal of barriers at their northern extremities reversed their flow. As noticed by Dr. Foote, their beds are, in the deepest places, from 50 to 100 feet below the level of tide-water.

Principal lakes in the drainage basin of the Oswego river.

Name of lake.	Elevation of water-surface above mean sea-level.	Authority for elevation.	Area of water-surface. (b)	Total drainage area above outlet of lake.	Remarks.
	Feet.		*Square miles.*	*Square miles.*	
Oneida lake	369.78	State canal profiles	80.90	1,300.0	Greatest estimated depth, 60 feet. Surface freezes entirely over, usually by January 1. Lake changes but slightly in level during the year. Used for steam-towing navigation. Outlet 16 miles long, with a fall of about 8 feet, and is practically of no value for power.
Cazenovia lake	900.00	French's *Gazetteer of New York*	2.80	9.0	Outlet (Chittenango creek) 25½ miles long, with a total fall of about 530 feet to Oneida lake. At Chittenango Falls there is an abrupt pitch of 136 feet, and there is an entire fall of 470 feet in the 9½ miles from Cazenovia lake to the state feeder-dam, where the storage from the lake is diverted to the Erie canal. The creek is used to a moderate extent for power, mainly by flouring- and paper-mills. Area of flowage is as shown on canal map.
Seneca lake	443.07	State canal profiles	66.00	707.0	34 miles long and from 1 to 2½ miles wide. Ordinary range from high to low water, from 2 to 2½ feet; extreme, from 4 to 5 feet. Temporary oscillations of a foot or two due to winds and tides are claimed to occur. Deepest sounding obtained up to 1880 was 580 feet. Scarcely ever does any ice form, except a slight skim occasionally near the extremities. Utilized for navigation. Outlet (Seneca river) falls 63 feet to Cayuga lake, and is largely employed for power at Waterloo and Seneca Falls. Thence to the junction with Oneida river the only use of power is at Baldwinsville.
Keuka or Crooked lake.	720.07	do	20.30	187.0	Some freighting and passenger traffic carried on by steamers. Lake is surrounded by hills. Over much of its extent the depth exceeds 200 feet. Annual variation from high to low water 5 or 6 feet, with extreme of 9 feet. Outlet falls 277 feet in 6 or 8 miles to Seneca lake, and is used for power by several flouring-mills.
Cayuga lake	380.07	do	66.75	1,593.0	Used for navigation, and nearly always free from ice except within 9 or 10 miles of the foot. Ordinary range from high to low water about 3 feet, with extreme of 7 feet. Deepest sounding, 435 feet. Drainage basin, exclusive of Seneca outlet, 813 square miles. Area of flowage measured on map prepared by students of Cornell university.
Canandaigua lake	687.50	Ordinary low water by profile of Northern Central railroad.	18.60	175.0	Commonly freezes over in part. Some freighting carried on over its surface. Depth estimated to be as great as 150 feet in the deeper portions, but is shallow toward the head and foot. Outlet falls 287.5 feet in 26 miles, to Lyons, and is used at various points for manufacturing.
Owasco lake	707.00	Old survey	12.40	208.0	Annual range between high and low water about 5 feet. Temporary oscillations of several inches, and even a foot, are caused by winds. Surface freezes over usually by February. The state has a dam at the foot of the lake, and another 9 miles below on the outlet, by the latter of which water is diverted to the Erie canal. The total fall in the outlet is 330 feet, and a large amount of power is in use, chiefly at Auburn.
Skaneateles lake	860.25	French's *Gazetteer of New York*	15.10	84.0	Has a narrow basin and is surrounded by high hills. Is usually frozen over from January till April. Deepest sounding, 320 feet. Tides claimed to occur, and sudden oscillations due to winds also noticed. Level highest in spring or early summer, and lowest toward the close of the year. Outlet about 13 miles long, with a fall, to the feeder-dam, of 450 feet, utilized by numerous mills, and offering many unimproved sites. Controlled by the state for feeding the Erie canal.
Onondaga lake	361.00 369.00	French's *Gazetteer of New York* Charles W. Foote	4.10	267.0	Greatest depth stated as 65 feet. No power on outlet.
Otisco lake	772.00	French's *Gazetteer of New York*	4.00	34.4	Water diverted from outlet (Nine-Mile creek) at Camillus for feeding the Erie canal. Outlet has a fall of 361 feet to the feeder-dam, and is employed for power by a considerable number of mills. Area of flowage measured on canal map.
Cross lake			3.90		Mere enlargement of Seneca river.

a *Notes upon the Geological History of Cayuga and Seneca Lakes.* b Measured on French's map of New York, except where otherwise stated.

The influence of the lakes upon the Oswego river is of the utmost importance in contributing to the steadiness of its flow. The conditions affecting it, aside from the presence of these natural reservoirs, are not favorable to uniformity. The country drained is underlaid to a considerable extent by permeable rocks—shales, sandstones, and limestones—its surface has been quite thoroughly cleared of timber, settled, and drained in the processes of cultivation, and the rainfall is rather light. Even as it is, the discharge at times falls as low as 1,150 or 1,250 cubic feet per second at Oswego, or only from 0.23 to 0.25 cubic foot per second per square mile of effective drainage area, although the ordinary summer flow is stated upon good authority to be twice as great. On the other hand, the flood volume runs as high as between 16,000 and 17,000 cubic feet per second in ordinary floods, and even rises to between 41,000 and 42,000 cubic feet per second in an excessive flood.

No record could be found of any long-continued series of measurements of the discharge, but the following data may be taken as reliable guides to the amounts of water flowing in low and in high stages of river:

1. By a decree of the supreme court, dated August 21, 1875, in the case of Michael J. Cummings against owners and lessees of water on the Varick canal at Oswego, it was assumed as follows concerning the amount of water flowing to this canal, which receives one-half the surplus of the river above the needs of navigation: (1) "That the average flow of water from the Oswego river into the Varick canal in low water in the summer months is about 45,000 to 50,000 cubic feet per minute", making the whole flow of the river say from 90,000 to 100,000 cubic feet per minute (from 1,500 to 1,670 cubic feet per second). (2) "That in extreme low water in the summer, and which usually occurs in the months of July or August, it is about 35,000 cubic feet per minute" (70,000 cubic feet for the whole flow of the river, or 1,170 cubic feet per second). (3) "That the average flow for the whole three summer months is about 75,000 cubic feet per minute" (150,000 cubic feet for the whole flow of the river, or 2,500 cubic feet per second).

2. It is stated by Charles Rhodes, esq., of the Oswego Canal Company, a gentleman who has given much observation and study to hydraulic questions connected with this river, that (1) in an ordinary flood the discharge at Oswego is, in round numbers, 1,000,000 cubic feet per minute (from 16,000 to 17,000 cubic feet per second); (2) in a large flood, 1,500,000 cubic feet per minute (25,000 cubic feet per second); (3) in an excessive flood, 2,500,000 cubic feet per minute (from 41,000 to 42,000 cubic feet per second).

3. In the *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879, an estimate is made of the supply of water available for navigation, in which it is assumed that the Seneca river may be relied upon for 54,000 cubic feet per minute, the Oneida river for 20,000 cubic feet per minute; while the Oswego canal receives from the Erie canal at Syracuse 10,000 cubic feet per minute, all of which, not lost on the way, is discharged into the Oswego river via the Seneca river. In all, therefore, the Oswego river is assumed to receive from 74,000 to 84,000 cubic feet per minute (from 1,230 to 1,400 cubic feet per second).

Summary of data concerning the flow of water in the Oswego river.

Locality.	Stage of river.	Drainage area, gross. (*a*)	Flow per minute. (*b*)	Flow per second.	Flow per second per square mile of gross drainage area.	Authority.
		Sq. miles.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	
Oswego	Average flow in low water in the summer months.	5,013	90,000–100,000	1,500–1,670	0.30–0.33	Volumes assumed in supreme court decree.
	Extreme low water in the summer, usually occurring in July or August.		70,000	1,170	0.23	
	Average flow for the whole three summer months.		150,000	2,500	0.50	
	Ordinary flood		1,000,000	16,000–17,000	3.19–3.39	Charles Rhodes.
	Large flood		1,500,000	25,000	4.99	
	Excessive flood		2,500,000	41,000–42,000	8.18–8.38	
Three-River Point.	Stage not mentioned, but presumably a low one.	4,868	74,000–84,000	1,230–1,400	0.25–0.29	Marvin Porter, engineer of middle division of New York state canals.

a Of which about 750 square miles is more or less completely utilized in the dry season for feeding the Erie canal.

b The amounts here given are in round numbers, the flow required for lockage, which is in comparison small, being neglected. Probably 3,000 cubic feet per minute, or 50 cubic feet per second, would be a reasonably large average allowance for waste and the demands of lockage.

Various tributaries of the Oswego river are drawn upon to supply water to the Erie canal during somewhat more than half the year. A certain proportion of this water may ultimately find its way into the main river, but its amount can not easily be estimated. An aggregate area of not far from 750 square miles, naturally draining to the Oswego river, is thus controlled and rendered partially tributary to the Erie canal. On the other hand, the Chemung river, flowing to the Susquehanna, is drawn upon to some extent for feeding down the Chemung canal into Seneca lake; and the extreme head-waters of Tioughnioga creek, also naturally flowing to the Susquehanna, are diverted for filling the DeRuyter reservoir, which feeds northerly down the course of Limestone creek to the Erie canal.

Table of streams in the Oswego basin having their waters diverted to the supply of the Erie canal.

Stream.	Location of feeder-dam.	Name of canal level fed.	Natural drainage area controlled.	Remarks.
			Sq miles.	
Oneida Creeek	Oneida	Long level	62	
Cowassalon creek	2 miles westerly from Oneida	do	23	
Chittenango creek	Chittenango	do	87	Includes Erieville reservoir and Cazenovia lake. From the latter down to the feeder-dam, say 9½ miles, the stored waters are available for power.
Limestone creek	Manlius	do	81	Commands in upper course the storage of DeRuyter reservoir, supplied by an artificial diversion of water from the head-waters of Tioughnioga creek, naturally draining to the Susquehanna. The drainage area given is independent of the Tioughnioga.
Butternut creek	4 miles southeast of Syracuse	do	47	Receives the storage of Janesville reservoir.
Nine-Mile creek	Camillus	Jordan level	77	Commands the storage of Otisco lake, the waters of which are for 11 miles, to the feeder-dam, available for power.
Carpenter brook	2½ miles east of Jordan	do	8	
Skaneateles creek	Jordan	do	114	Commands the storage of Skaneateles lake, the waters of which are for between 11 and 12 miles, to the feeder-dam, available for power.
Putnam brook	Weedsport	Port Byron level	28	
Spring brook	Centerport	do	4	
Owasco creek	Port Byron	do	222	Commands the storage of Owasco lake, the waters of which are for say 9 miles, to the feeder-dam, available for power.
			753	

The fall in the river from Three-River Point to the average surface of lake Ontario is 115 feet, which is accomplished partly at dams, partly in rapids, and at Oswego Falls includes an abrupt pitch of several feet. The Oswego canal, striking off from the Erie canal at Syracuse, follows down the east shore of Onondaga lake to the Seneca river; thence to Three-River Point and down the Oswego river, navigation is maintained by a series of seven dams, the slack-water of which is taken advantage of, while stretches of canal make the descents around the dams and rapids from one pool to another. All these dams have been constructed in the most substantial manner, and are owned by the state. It having been established by legal decision that the surplus water at these dams may be used by private parties to supply power for manufacturing-purposes, in so far as there is no interference with navigation or the state's improvements, a number of extremely valuable water-powers have thus been made available, and at four points—Oswego, Fulton, Oswego Falls, and Phœnix—are now put to use, and support important manufacturing interests. The stream is, in general, finely adapted to the convenience and security of such employment. The bed and banks are firm, the latter of good height. The volume of water is maintained with great steadiness, and there is freedom from disastrous freshets. On the Oswego dam, having a roll-way of 530 feet, the greatest freshet-depth is stated not probably to have exceeded 6 feet; and below the Minetto dam the ordinary rise is only 3 or 4 feet. The whole surrounding and tributary country is prosperous and rich in resources. The best of water communication is enjoyed, either by way of the great lakes or the New York state canals. The west bank of the river is followed by the Oswego and Syracuse division of the Delaware, Lackawanna, and Western railroad, and the east, below Fulton, by the New York, Ontario, and Western railroad.

The principal hinderance encountered in using water-power on this river is from backwater, caused either by freshets or by ice. The stream sinks slowly from a flood-stage, and for from two to four weeks considerable trouble is experienced at Phœnix from backwater, with even a forced stoppage of work in exceptional cases, but the wheels there are said to be generally designed to use a large amount of water under a moderate fall, to meet such difficulty. Opposite the Varick canal, at Oswego, the net reduction of head in freshets does not exceed 2½ or 3 feet. On the lower river, so far as can be learned, neither anchor- nor floating-ice is especially troublesome, but at the former site of the "horseshoe" dam, between Oswego Falls and Phœnix, anchor-ice collects and sets the river back so as at times nearly or quite to destroy the head at the latter point. A few years ago the river was in this manner set back for seven weeks over the top of the Phœnix dam. The anchor-ice formed a gorge at the "horseshoe" dam, said to have been nearly 20 feet high in places, and to have extended a mile up stream.(*a*) It was generally considered an impracticable thing to clear the river of this gorge, but by determined effort a passage was cut through in a few hours.

a This is the only locality that has been brought to the notice of the author, on any stream, where extensive gorges have resulted from the accumulation of true anchor-ice, but careful inquiries indicated that it was this form of ice, and not cake- or skim-ice, which caused the river to become choked up at the "horseshoe" dam.

Table showing elevations and fall of the Oswego river.

Locality.	Distance from mouth, map measurement.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevation.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Three-River Point, head of river	20.6	361.93	115.32	20.6	5.6	359.86 feet + mean low tide at Albany. New York state canal profiles.
Mean surface of lake Ontario	0.0	246.61				Mean elevation from January 1, 1860, to December 31, 1875, above mean tide at New York, as stated at office of Chief of Engineers, U. S. army.

Water-power at Oswego.—The city of Oswego, with a population of 21,000, is located at the mouth of the river, which widens out into a fine harbor. The stream-bed is composed of low outcropping sandstone ledges, forming rapids at the head of which is the state dam. This curves up stream in plan, and has a vertical face, a timber apron, and heavy masonry abutments rising 6 feet above the crest. The main structure is of stone, with spill-way 530 feet long, and rises some 12 feet above bed-rock. The apron is about 3 feet high, projects 15 feet down stream from the foot of the dam, and is covered with timbers 10 inches thick. The east abutment is 7 feet wide on top, and from it a wing-wall of about the same width extends back to form one side of the navigation canal, which here opens out from the pool and passes around the dam and rapids. Under the tow-path of this canal water enters the Oswego hydraulic canal, running parallel to the former and on the inshore side of it, and at a distance of 450 feet below the entrance is controlled by a timber bulkhead supported by three stone piers, each 5 feet wide. There are 13 gates, with openings about 5 feet 4 inches wide in the clear; each gate is worked by a screw of about 2 inches diameter, power being applied by a lever. Shortly above this bulkhead an additional gate, with an opening 6 or 7 feet wide, communicates with the navigation canal.

The power on this, the east side of the river, not already disposed of, is owned by the Oswego Canal Company. This company's canal is about 4,000 feet long, has a water depth of 6 feet, and an average width at water-surface of probably 60 feet; the latter dimension varies, however, and is greater than 60 feet in the upper part of the canal, decreasing toward the lower end. With 1-foot flash-boards on the dam, the fall to average lake-surface may fairly be stated as 20 feet; but it varies with the lake-level,(*a*) from month to month, and from year to year, and with full canal and low lake has been known to reach 25 feet. The fall in actual use ranges commonly from 12 to 20 feet, according to position on the canal, the latter extending down to the harbor. Some facts regarding the manufacturing along this canal are given below:

Establishments using power on the Oswego hydraulic canal, November, 1882.

Firm.	Kind of mill or manufacture.	Remarks.
Oswego Starch Factory	Power used in grain elevator	Lowest establishment on the canal; capacity of elevator, 200,000 bushels.
Smith, Murdock, & Co	do	Capacity of elevator, 225,000 bushels.
M. Merrick & Co	Flouring-mill and elevator	Daily capacity of mill, 500 barrels of flour; storage capacity of elevator, 200,000 bushels.
Penfield, Lyon, & Co	2 flouring-mills and an elevator	Lower mill, rollers, 600 barrels per day; elevator capacity, 300,000 bushels; upper mill, rollers, 500 barrels per day.
C. C. Morton	Power used in elevator	Capacity of elevator, 250,000 bushels.
Thomas Matthews	do	Capacity of elevator, 230,000 bushels.
B. Doolittle & Co	Flouring-mill	Capacity of mill, 125 barrels per day; 150,000 bushels of corn also ground yearly for meal.
James McFarland & Co	Wood-pulp	
C. W. Pardee	Malt-house	Malting capacity, 125,000 bushels per year.
Oswego Wood Pulp Company	Planing-mill, and sash-and-blind factory	
Francis Perot's Sons	Malt house	
Switz, Condé, & Co	Knit underwear	9 sets of machinery; value of annual production, about $650,000.
Charles North	Large tannery	
Oswego Flux Company	Flux for softening iron	Uses a fall of 14 feet and a wheel of about 25 horse-power.
Scott & Nesbit	Dry-dock	
Lyon & Mott	Malt-house	Malt-house 4 stories high, 130 by 72 feet in plan, cost $40,000; storage for 60,000 bushels of grain; malting capacity, 110,000 bushels of barley during the season of seven months, from October to May; 20 horse-power wheel, under a head of 14 feet, used for elevating and conveying the grain.

a From an article by Charles Rhodes, esq., of Oswego, based upon observations contained in the reports of the Chief of Engineers, U. S. army, are taken the following facts: At Oswego there is a range of 4.76 feet between extreme high water of 1838 and extreme low water of 1846 and 1848. Several different classes of oscillations occur in the surface of the lake. The means for successive periods of five years show a slow general movement, covering in the progression from high to low water, or the reverse, from ten to twenty years' time. The mean monthly levels for any one year show a change from high water, which occurs most often in May or June, though frequently in July, to low water, which is nearly always in December or January. Sudden and unaccountable variations of level also take place. Thus, "for example, in April, 1873, after eighteen months of very low water, lake Ontario rose 2½ feet in about twenty days".

A certain necessary amount of water is first of all required by the state for its canal, and in order to maintain the slack-water level above the dam the pool is not permitted to be drawn down more than 1 foot, probably to the stone crest of the dam; in practice it is always kept very nearly full. Of the water entering the navigation canal a portion is drawn and used by two or three concerns on its upper course, this being allowed by the state in order to avoid the expense of culverts under the canal, which would be necessary if the supply were taken from the hydraulic race; but culverts are also employed in one or two cases. The hydraulic race was built about 1823, before the navigation canal. Below the lower bridge over the river it passes most of the way under the buildings along its course and is opposite navigable water in the stream.

The Oswego Canal Company gives a 999-year lease of water, but land has to be bought by manufacturers from other parties; much unoccupied room, however, is owned by an estate interested in the company. On the lower part of the canal, near the elevators, are two good sites, one formerly occupied by the Lake Ontario mills, 6 runs, and the other by a 4-run mill and an elevator. The buildings were burned and the sites are now vacant.

A "run" of water on this canal is 11¾ cubic feet per second, under the head available at the harbor, say 20 feet. There are assumed to be 32 first-class runs, the annual rental for which is $350 per annum per run; 32 second-class runs, at from $250 to $300 per annum per run; while the balance are surplus runs and bring from one-half to two-thirds the rental charged for first-class runs. In case of a shortage of water the surplus runs would first be shut down successively, in order beginning with the most recent leases; then the second-class runs would share equally with one another in a reduction, and finally, if necessary, the first-class runs would similarly be cut down. In practice all the mills at present on the canal can run their wheels at full capacity as many as eleven months in the year. November 27, 1882, there had been leased on this race 30 first-class runs, about 15 second-class, and about 16 surplus runs.

Table showing the cost of water-power on the Oswego hydraulic canal.(a)

[A run is here assumed as 11¾ cubic feet per second under a head of 20 feet=26.7 theoretical horse-power.]

Assumed efficiency of wheels.	Corresponding effective horse-power.	Cost per effective horse-power.			Assumed efficiency of wheels.	Corresponding effective horse-power.	Cost per effective horse-power.		
		First-class runs at $350.	Second-class runs at from $250 to $300.	Surplus runs at from ½ to ⅔ first-class			First-class runs at $350.	Second-class runs at from $250 to $300.	Surplus runs at from ½ to ⅔ first-class.
Per cent.	*Per run.*				*Per cent.*	*Per run.*			
60	16.02	$21 85	$15 61–$18 73	$10 92–$14 57	75	20.02	$17 48	$12 49–$14 99	$8 74–$11 65
65	17.35	20 17	14 41– 17 29	10 08– 13 45	80	21.36	16 39	11 70– 14 04	8 19– 10 93
70	18.69	18 73	13 38– 16 05	9 37– 12 49	85	22.69	15 43	11 02– 13 22	7 72– 10 29

a See subsequent remarks on comparative cost on Oswego and Varick canals.

On the west side of the river is the Varick hydraulic canal, extending 3,000 feet down from the state dam, but necessarily brought to an end before reaching navigable water owing to the abrupt and rocky character of the bank and the occupation of the ground by other improvements. It is in general about 60 feet wide in its upper course, furnishes a fall ranging between 10 and 15 feet, according to location, and is utilized for manufacturing as follows:

Establishments using power on the Varick hydraulic canal, November, 1882.

Firm.	Kind of mill or manufacture.	Remarks.
Joseph Hover	Flouring	Fall of 10 feet Owns 5 first-class runs. Capacity of mill, 250 barrels per day.
T. Kingsford & Son. (The Oswego Starch Factory.)	Starch	The firm owns 26 first-class and 12 second-class runs. Fourteen water-wheels are run, furnishing in the aggregate 1,220 horse-power; 845 horse-power of steam is also available for use in low water. The firm has manufactured continuously for over 50 years, and in 1848 removed here from Jersey City. The production is 35 tons per day, or 21,500,000 pounds of starch per year. The works cover 5 acres of ground, and the principal buildings have a frontage of 733 feet and a depth of 200 feet. They contain 38 miles of steam-pipe, 5 miles of shafting, 24 pairs of burr-stones for grinding corn, and 6 pairs of heavy iron rollers.
O. H. Hastings & Co	Flouring	Eight runs of stone, 6 sets of rollers. Capacity of mill, 300 barrels per day. The firm owns 6 first-class runs and 1 second-class.
Nutting & Wright	Printing-paper	Production, 2 tons per day.

The Varick canal was built in 1834, and is said to have cost $112,000. So far as owning water-rights not yet leased and receiving rents are concerned, the proprietors are M. Pardee and the F. T. Carrington estate, owners also of the adjoining unoccupied land. A perpetual lease of water is given to manufacturers desiring power. As affirmed by a decree of the supreme court,(*a*) a run of water on this race ranges between 1,700 cubic feet per minute under a head of 12 feet and 1,500 cubic feet under a head of 13 feet; it may fairly be taken as 2,000 cubic feet per minute (33⅓ per second) under a head of 10 feet, or its equivalent. There are recognized 50 first-class runs, 17 second-class, and an unlimited number of third-class. For first-class runs the rental is from $250 to $300 per annum;

a Dated August 21, 1875. Case of Michael J. Cummings against owners and lessees of water on the canal.

for second- and third-class runs it ranges from $125 to $150. November 28, 1882, there had been leased permanently 45 first-class runs and 14 second-class. Five first-class runs had also been temporarily leased, and these, together with about 35 second- and third-class, remained applicable to unsold and unoccupied lands, which include abundance of good building-room. The second-class runs are stated to be reliable for power nine or ten months in the year. At times they have been shut down to about one-quarter of their full amount, and for one or two months the Oswego Starch Factory has, in a very low stage of river, been obliged to bring into use 800 horse-power of steam.

Table showing the cost of water-power on the Varick hydraulic canal. (*a*)

[A run is here assumed as 33$\frac{1}{3}$ cubic feet per second under a head of 10 feet = 37.87 theoretical horse-power.]

Assumed efficiency of wheels.	Corresponding effective horse-power.	Cost per effective horse-power.		Assumed efficiency of wheels.	Corresponding effective horse-power.	Cost per effective horse-power.	
		First-class runs at from $250 to $300.	Second- and third-class runs at from $125 to $150.			First-class runs at from $250 to $300.	Second- and third-class runs at from $125 to $150.
Per cent.	*Per run.*			*Per cent.*	*Per run.*		
60	22.72	$11 00–$13 20	$5 50–$6 60	75	28.40	$8 80–$10 56	$4 40–$5 28
65	24.62	10 16– 12 18	5 08– 6 09	80	30.30	8 25– 9 90	4 13– 4 95
70	26.51	9 43– 11 32	4 72– 5 66	85	32.19	7 77– 9 32	3 88– 4 66

a See subsequent remarks on comparative cost on Oswego and Varick canals.

The Oswego and Varick canals are entitled to divide the water of the river, not needed for navigation, equally between them. In order to do this both have the same aggregate water-way at the head-gates, and by gauges at those points, which are examined when necessary, it can be seen if one canal has been drawn below the other, and the gates can be changed accordingly. On the Varick canal each mill draws its water over a weir,(*a*) which is adjusted from time to time by commissioners and locked in such position that the flow over it shall be what the mill is entitled to receive. Of course, if in low water the level should be drawn down a little the flow over each weir would be slightly and proportionately decreased. On the Oswego canal there is no such contrivance, and more reliance is placed on the wheels as guides to the amounts of water used. On the Varick canal all the establishments are between the canal and the river; on the line of the Oswego hydraulic canal they are between it and the river, but along the upper course some are on one side and some on the other of the navigation canal.

From the tables that have been given it will be seen that the cost of water is apparently much less on the Varick than on the Oswego canal, and without some explanation an erroneous impression may be gained. In the first place, the Oswego hydraulic canal has a substantial advantage over the Varick canal in that it extends to the harbor, thus enabling vessels from the upper lakes to come directly alongside the mills; by this the intrinsic value of the power is increased. Secondly, a first-class run of water can always be depended upon along the Oswego canal, but can not along the Varick canal. No means are at hand of determining with accuracy the actual mean fall which pertains to the entire series of first-class runs on either canal; but judging from the statements contained in the decree of the supreme court, and from such general information as has been obtained concerning the positions of the mills, it may be fair to assume, in view of the actual distribution of the runs in use along the canals, the following as the mean of all the first-class runs:

On the Varick hydraulic canal, 1,600 cubic feet per minute (26$\frac{2}{3}$ per second), under a head of 12$\frac{1}{2}$ feet.

On the Oswego hydraulic canal, 783$\frac{1}{3}$ cubic feet per minute (13.06 per second), under a head of 18 feet.

It appears, then, that under the conditions of actual practice, the 50 first-class runs on the Varick canal, when all in use, must demand about 80,000 cubic feet of water per minute (1,333 per second), while the 32 first-class runs on the Oswego canal will demand but about 25,000 cubic feet per minute (25,067 more nearly, or 418 per second).

Taking the flow of the river as assumed by the court, and supposing all the first-class runs in use, we have, then, the following three cases:

(1) Extreme low water in summer, flow into Varick canal (and presumably the same into the Oswego canal) about 35,000 cubic feet per minute. An average first-class run on the Varick canal must then be abated to 44 per cent. of its full value, while there will be no abatement on the Oswego canal of first-class runs.

(2) Average flow in low water in the summer months, from 45,000 to 50,000 cubic feet per minute. First-class runs on the Varick canal will then be abated to from 56 to 62 per cent. of their full value. On the Oswego canal there will be no abatement of first-class runs, and a very slight one, if any, of second-class.

a In the decree of court already alluded to, it is, among other things, "ordered adjudged and decreed: That it is necessary in order to obtain the greatest head of water in the canal, and to give the most power practicable to the several runs of water, and for the interest of all the parties, that the water to be drawn and taken from the canal by all the parties hereto, their heirs and assigns, as soon as practicable hereafter, and under the direction and control of the commissioners hereinafter appointed, be drawn and taken over weirs with curved crests, the curve of such crests to be as near as may be to ninety degrees of a circle the radius of which shall be 4 inches, and that the weirs be so adjusted that the second-class water may be readily abated or shut off, and so that the first-class water may be readily abated, and so as to secure as much head in all cases as is practicable, and that the water be drawn by gates to be raised from below".

(3) Average flow for the whole three summer months, about 75,000 cubic feet per minute. First-class runs on the Varick will then have about 94 per cent. of their full value, while on the Oswego canal there will be a large surplus beyond the needs of both first- and second-class runs.

In accordance with the general plan of estimates heretofore used, the probable flow and power at Oswego may be placed at the following figures:

Estimate of power at Oswego.

Stage of river.	Rainfall on basin.					Drainage area, gross.	Whole flow of river per second, average for the 24 hours.	Flow to each hydraulic canal per second. (a)	Theoretical horse-power.			Total effective horse-power (rated) of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.				For each hydraulic canal, per foot of fall.	Total for Oswego hydraulic canal, assuming mean fall at 18 feet.	Total for Varick hydraulic canal, assuming mean fall at 12½ feet.	
	Ins.	Ins.	Ins.	Ins.	Ins.	Sq. miles.	Cubic feet.	Cubic feet.				
Low water, dry year							1,200	575	65.3	1,170	820	Partial returns give 2,350 horse-power. This does not include the power used in 4 elevators, a paper-mill, a pulp-mill, a dry-dock, and 2 malt-houses.
Low water, average year	8	10	9½	7	34½	b 5,012	1,550	750	85.2	1,530	1,060	
Available 10 months, average year.							2,350	1,150	130.6	2,350	1,630	

a Assumed at half the entire flow after allowing 50 cubic feet per second for lockage and accompanying waste.
b Of which about 750 square miles is more or less completely utilized in the dry season for feeding the Erie canal.

Powers above Oswego.—Two miles from Oswego is the "high" dam. It is a straight structure of stone, with roll-way 363 feet long and probably 13 or 14 feet high. It is said that the river-bed is here gravelly and that the dam rests upon crib-work. It is provided with an apron having first a downward slope and then running horizontally. In the dry season flash-boards 1 foot high are placed on the crest of the dam. The abutments are of very heavy masonry, that on the west side being 10 feet wide at the top. A canal passes around the east end of the dam, after which boats ascend in the slack-water as far up as the rifts between this and the Minetto dam. The only use of power here is at the Oswego pumping-works at the west end of the dam. Through a timber bulkhead with stone piers water is admitted to a race about 20 feet wide, and passes a short distance to the pump-house. The water-wheels run under a head of 15 feet and furnish power for pumping into reservoirs on each side of the river, whence the city receives its supply. The banks are high and bluffy on both sides, and the opportunities for extensive building are unfavorable; still there is a moderate amount of available room, and space remains for one mill of good size between the bulkhead and the pump-house.

At Minetto, a little village 3 or 4 miles above Oswego, the river is from 450 to 475 feet wide, with a gravelly and stony bed, rapids and rifts reaching a long distance below the dam. The latter is a stone structure, with a roll-way 445 feet long, masonry abutments, and a crib-work apron. It is said to have been built in 1871. The height is about 7½ feet without, or 8½ feet with, the flash-boards commonly in use. The navigation canal ascends around the rifts and dam on the east bank, and then enters slack-water again. From the dam, for 160 feet down to the road bridge which there spans the stream, there is a clear space of 45 feet between the canal and the river, protected next the latter by a masonry wall. Below the bridge the distance between canal and river grows less. The power on this side of the river was stated to be owned by Mr. M. Merrick, of Oswego. There was once a large flouring mill here, but it was burned and only the ruins remain. On the inshore side of the canal a high gravelly bank rises abruptly.

At the west end of the dam there is an old saw-mill, now unemployed except as a shop in connection with the adjoining factory, and containing the wheels from which, by two shafts at right angles to each other, power is conveyed to the works. An extreme fall of 9 feet, and two 30 horse-power wheels, are employed by the Minetto Shade Cloth Company. The annual production of cloth amounts to 2,500,000 yards, and employment is given to 50 hands. This company owns all the power on one side of the river and the land adjoining the latter for a long distance, but is willing to accommodate other manufacturing concerns. The river-bank is of moderate height, and a race could easily be extended alongside of it by continuing the present river-wall; in fact, at this point power might conveniently and largely be utilized on either side of the stream. There is a railroad a third or a half mile away from either bank. A spur has been surveyed on the west side from the Delaware, Lackawanna, and Western railroad and will be built, it is said, if there is sufficient business to warrant it. There is some unimproved fall both above and below Minetto, but whether sufficient to constitute in either locality another privilege of importance is not shown. Slack-water navigation continues a short distance above the Minetto dam, and then a canal is again resorted to.

At Battle island, some 2 miles above Minetto, there is a straight stone dam, with a sloping timber apron extending about half way its length, which is 662 feet between abutments. This is known as the Van Buren dam, and, like the others on the river, is owned by the state. The river bed is here gravelly and stony, with rapids stretching several hundred feet down stream, and falling probably 2 or 3 feet. At the south or left end of the dam the fall over the latter is naturally about 4½ feet, increased to from 6 to 6½ feet by flash-boards. There is a

heavy masonry bulkhead, with gate-openings closed by temporary work, at this end of the dam, and the facilities for using power are good. No power is actually employed, however, either on this or on the opposite side of the river, though it was said that on the latter, which has the advantage of being adjacent to the navigation canal, but which was not visited, there had formerly been starch-works and some other establishments.

The next privilege to be noticed is at the village of Fulton, a place of about 3,900 inhabitants, lying on the east bank of the river, between 11 and 12 miles from its mouth. The state has here two stone dams, about 3,000 feet apart, the Oswego canal making the passage around the falls on the Fulton side. The lower, known as the Fulton dam, extends straight nearly the whole distance across the river, and has a roll-way 503 feet in length. The fall at the east end, from crest to water-surface below, is about 13½ feet, and heavy rapids reach from 700 to 1,000 feet further down stream. Near the dam the river-bed is mainly composed of low ledges, with considerable loose rock. The navigation and hydraulic canals open out side by side from the pool above the dam, the hydraulic canal lying the nearer to the river, between which and itself the mills are chiefly situated. Water for power is admitted through a timber bulkhead about 40 feet long, in which are six gates operated by screws.

Manufacturing at the east end of the Fulton dam (fall of 1882).

Firm.	Kind of mill or manufacture.	Remarks.
Herrick & Emerick	Wooden boxes	Have two shops. At the upper, water is drawn directly from the pond under about 15 feet fall, 140 horse-power of wheels being in use. At this shop 35,000 feet of lumber is cut up daily, and 5,000 boxes are turned out in the same time. At the lower shop about 1,000,000 feet of lumber is used yearly.
W. S. Nelson & Co	Flouring	10 runs of stone. Capacity of mill, 600 barrels per day. Property said to be owned by the estate of Jesse Hoyt, of New York, deceased.
Perine & Wright	Custom- and flouring-mill	5 runs of stone; capacity of mill, 100 barrels per day.
W. G. Gage & Co	Flouring	17 sets of rollers; capacity of mill, 300 barrels per day.
Gardner & Seymour	Flouring	Capacity of mill, 250 barrels per day.
Patterson & Smith	Custom-mill	3 runs of stone.
R. N. Hoff	Custom- and flouring-mill	3 runs of stone.
Gilbert Brothers	Custom- and flouring-mill	4 runs of stone.
Victoria Paper Mill Company	Pulp and manila paper	Uses 12 or 13 feet of fall and about 250 horse-power of wheels. Production, 1 ton of pulp, dry weight, per day; and from 1,500 to 5,000 pounds per day of paper, according to kind.
Taylor Bros. & Co	Machine-knives	Employ 16 hands.

In addition to the more important establishments mentioned above, power also is used in a 2-run plaster-mill and in a number of small shops of various kinds. The power on this race is said formerly to have been developed by a private firm which afterward sold off rights to different manufacturers. The privilege is nominally divided into 50 runs, a run being defined as 144 square inches of water under a head of 12 feet, and the expenses of repairs are shared according to the number of runs owned. There is much transferred water, no system of measurements is employed, and in many cases concerns probably use more water than the amounts to which they are entitled. The falls at the mills range in general between 12 and 16 feet, and cables are in several instances employed in transferring small powers. The hydraulic race is too small for the demands made upon it, becomes drawn down from 1 to 3 feet at the lower extremity in low stages of water, and an occasional stoppage of work thus becomes necessary to some of the mills. It is estimated that on the average all the mills can run at full capacity nine months in the year, and at three-quarters capacity the remainder of the time.

New manufacturing enterprises could obtain power here by purchasing from present holders. The privileges belonging with the Nelson and Perine & Wright mills could thus be obtained, and are said to control together probably half the water on the race. Although the river here affords a fine power, Fulton is not regarded as a favorable site for manufacturing, on account of the heavy taxes brought on by granting railroad aid, and stated to amount annually to 3¾ per cent.

At the west end of the Fulton dam the privilege is owned by Schuyler Schenck, of Toledo. The principal users of power are William Waugh & Brother, manufacturers of straw- and all other kinds of wrapping-paper, their production being 2 tons per day. Thirteen or fourteen feet of fall and 80 or 90 horse-power of wheels are employed. A small amount of power is also utilized in a quarry, tool-shop, and saw-mill, but a large surplus remains, half the entire flow of the stream belonging to the privilege on this bank.

At the upper privilege the river is crossed by what is known as the Oswego Falls dam, a low structure 413 feet long, and not more than 2 or 3 feet high, except as the crest is artificially raised by flash-boards, which are used in summer. Perhaps 100 feet below the dam an irregular ledge of red sandstone runs diagonally across the river, forming an abrupt pitch of 6 or 7 feet. Rapids succeed for several hundred feet down stream, and the river-bed is covered with loose slabs of rock. The main use of power is at Oswego Falls, a village of 1,800 inhabitants, on the west bank of the river, where are the extensive works of the Oswego Falls Manufacturing Company, the production of which is in all-worsted goods, including suitings and coatings, Italian cloth, serges, lastings, buntings, and dress-goods. This company runs 600 looms and gives employment to 1,100 hands. The fall obtained is 13 feet, and for ordinary use 9 water-wheels are run—seven 66-inch American turbines and two 56-inch Leffel

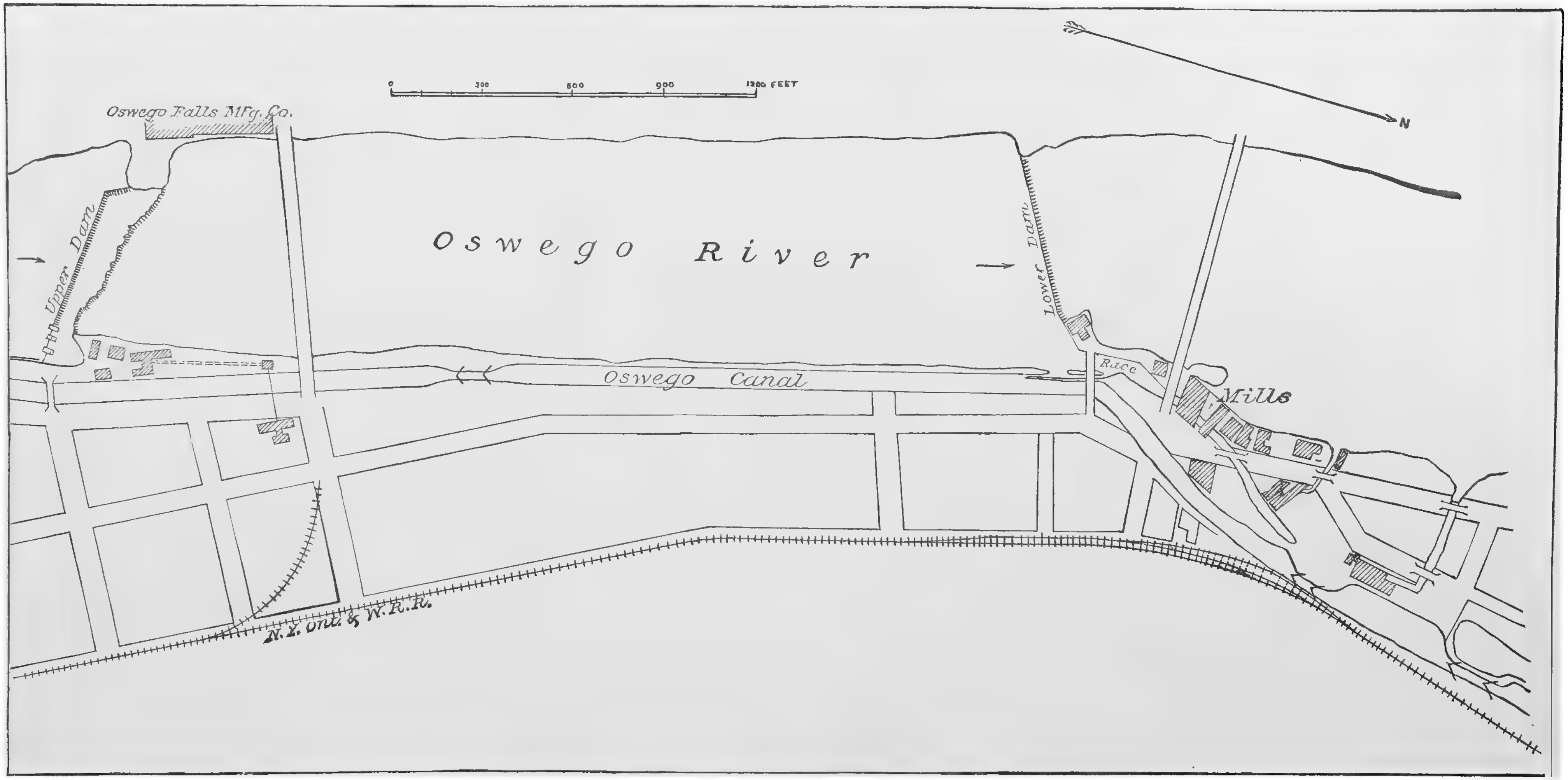

FIG. 5.—Plan of water-privilege at Fulton.

turbines—one of the latter for electric lighting. A small wheel is connected with the fire-pumps. There is nearly always a wastage of water over the dam, but there seems to be no convenient opportunity for further use of power on the Oswego Falls side of the river.

On the east or Fulton side the privilege is owned by Nelson Beardsley, of Auburn; it includes a frontage of about 800 feet along the navigation canal and the river, and a width of strip between them varying in the upper part from 50 to 125 feet. Water is admitted through three 20-foot openings between masonry piers to a short race, and through that and a connecting wooden flume is conveyed some 300 feet to a small saw- and plaster-mill. A grist-mill is also standing, but has not been in operation for a long time. A trunk extends some distance further, under the heel-path of the canal, to a wheel-pit from which power is transferred across the canal, by a shaft 125 feet or more in length, to E. W. Ross & Co.'s machine-shop and foundery, employing 100 hands and 170 horse-power of wheels. A head of 15 feet is obtained in low water, without flash-boards on the dam.

Estimate of power at the Fulton and Oswego Falls dams.

Stage of river.	Drainage area, gross.	Gross flow per second, average for the 24 hours.	Net flow per second, allowing 50 cubic feet for lockage and waste.	Theoretical horse-power.			Effective horse-power of wheels in use.
	Sq. miles.	*Cubic feet.*	*Cubic feet.*	*1 foot fall.*	*16 feet fall. (b)*	*15 feet fall. (c)*	
Low water, dry year	a 4, 931	1, 180	1, 130	128. 4	2, 050	1, 930	3, 130+
Low water, average year		1, 530	1, 480	168. 1	2, 690	2, 520	
Available 10 months, average year		2, 310	2, 260	256. 7	4, 110	3, 850	

a Of which about 750 square miles is more or less completely utilized in the dry season for feeding the Erie canal.
b Extreme amount assumed as available below the Fulton dam.
c Assumed as available below the Oswego Falls dam.

About 6 miles above Fulton there is a guard-lock in the canal, and opposite there was formerly what was known as the "horseshoe" dam, described as having been but a few feet high. It has been removed, and there is now nothing to indicate its former position except a short but heavy rapid, and a stone abutment on the left bank. Both banks have a gentle slope.

The last dam on the river, at Phœnix, is a mile or so below the junction of the Oneida and Seneca rivers. It is a stone structure, with a fall of about 7 feet from crest of flash-boards, a straight roll-way of 440 feet, masonry abutments, and an apron of timber crib-work bolted to bed-rock, half-way across sloping away from the dam, and the rest of the distance horizontal. Rapids extend several hundred feet down stream, but the fall obtained at the mills is in general about the same as that at the dam, or 7 feet. On the west side of the river water enters a race through three 20-foot openings, and runs 150 or 200 feet to the first establishment using power—Sweet, Northrop, & Co.'s furniture and burial-casket manufactory. This firm owns 2,000 inches of water under a head of 7 feet, employs 20 or 30 hands, and uses 50 or 60 horse-power of wheels. Two-thirds of the remaining power on this side belongs with property lying between the bulkhead and this factory, is unemployed, and is for sale. The other third is owned by Mr. E. Merry, and is utilized, partly at least, in the manufacture of tissue-paper.

On the east side of the river, in the village of Phœnix, a place of 1,300 inhabitants, a portion of the concerns are supplied by a hydraulic race, while the remainder are independent of it. At the end of the dam there are two 6-foot wheels, each of 65 horse-power, running under a fall of 7 feet. A shaft 109 feet long extends thence to the Phœnix Plaster Mill Company's works, whence three cables run distances of from 150 to 650 feet and supply power to the Central City Knife Company, employing 35 hands and turning out about 1,000 dozens per month of pen and pocket cutlery; the Phœnix Manufacturing Company's foundery, and a small cigar-box shop.

A separate flume also conveys water to Glass, Breed, & Co.'s flouring-mill (13 sets of rollers, 3 runs of stone, 200 barrels capacity), using a fall of 5 feet and about 120 horse-power of wheels; and from a tower at the end of the dam a cable transfers power to J. H. Loomis & Son's planing-mill and box-shop, employing 10 hands and about 50 horse-power.

Estimate of power at the Phœnix dam.

Stage of river.	Drainage area, gross.	Gross flow per second, average for the 24 hours.	Net flow per second, allowing 50 cubic feet for lockage and waste.	Theoretical horse-power.		Effective horse-power of wheels in use.
	Sq. miles.	*Cubic feet.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*	
Low water, dry year	a 4, 870	1, 170	1, 120	127. 2	890	b 540+
Low water, average year		1, 510	1, 460	165. 9	1, 160	
Available 10 months, average year		2, 280	2, 230	253. 3	1, 770	

a Of which about 750 square miles is more or less completely utilized in the dry season for feeding the Erie canal.
b Returns incomplete.

The hydraulic race is 40 feet wide. It is assumed to supply a certain number of inches of water, of wh 2,200 are owned by Pierce & Breed, who have a 4-run custom- and flouring-mill; 300 by A. W. Sweet & (manufacturers of caskets and coffins; and part in connection with a small saw-mill.

As has been noticed in the general remarks upon the river, much hinderance is experienced at this locality fr the backwater caused by freshets and by gorges of anchor-ice in the river below.

Summary of the principal water-powers on the Oswego river.

Locality of dam.	Approximate distance from mouth of river.	Drainage area, gross.	Assumed fall on privilege.	Estimated theoretical horse-power. Low water, dry year.	Low water, average year.	Available 10 months, average year.	Effective horse-power of wheels in use.	Principal kinds of manufacturing.
	Miles.	*Sq. miles.*	*Feet.*					
Phœnix	19½	4,870	7	890	1,160	1,770	540+	Flour, cutlery, cast goods, furniture, burial-caskets, paper.
Oswego Falls	12½	4,931 (Oswego Falls and Fulton)	15	1,930	2,520	3,850	3,130+ (Oswego Falls and Fulton)	All-worsted goods at Oswego Falls; machinery on Fu side.
Fulton	11¾		16	2,050	2,690	4,110		Paper on west side; on Fulton side, flour, paper, macl knives, and wooden boxes.
Battle island	6¾	4,998	8	1,040	1,360	2,090	00	
Minetto	4½	5,001	9	1,180	1,530	2,350	60	Shade-cloth.
High dam	2¾	5,009	15	1,960	2,560	3,920	200	Power used to pump water for the supply of Oswego.
Oswego	1	5,012	a 12½–18	1,990	2,590	3,980	2,350+	Flour, starch, paper, knit underwear, and leather. Po is also used in a number of large grain-elevators and m houses.
Total for falls as here assumed				11,040	14,410	22,070	6,280+	

a See detailed estimate of power at Oswego.

It is generally the case upon this river that the mills are either so clustered about the dams, or are so scatte along below them, that the available supply of water is not used under the full head which might be obtained the foot of the rapids, and consequently the best effect is not secured. The entire falls given in the above ta are, on that account, in many cases not really practicable with the present improvements, and could be realized, w the mills located as now, only by considerable outlays in deepening tail-races and perhaps clearing the ri channel at some points. They are approximate only, as data for accurate statements in detail concerning t fall along the river could not be obtained, but they will perhaps serve as a basis for conveying an idea of the gr power which would be afforded with suitable works.

TRIBUTARIES OF THE OSWEGO RIVER

ONEIDA RIVER AND LAKE.

This lake is distant, at the nearest point, between 10 and 12 miles in a northeasterly direction from Syracu and is surrounded by the counties of Oswego, Oneida, Madison, and Onondaga. It has a length of 20½ miles, extreme width of nearly 5½ miles, and a surface area of about 81 square miles. The total tributary drainage area abo Brewerton, where the outlet begins, including the lake itself, is 1,300 square miles. The principal tributary strea are Fish, Chittenango, and Oneida creeks, the two latter being drawn upon in part for supplying the Erie can A considerable portion of the north shore is high and bluffy, but at other points much of the land immediat bordering the lake is low and even marshy; farther back there is a rise to level or rolling country, fertile, and or moderately timbered. The lake has clear water, a firm bottom composed of gravel and clay, and is quite shallo the depth being estimated to range in general from 20 or 30 feet downward, and at no point to exceed 60 fe The surface is said to freeze entirely over, usually by the 1st of January or before, and during the year chan but slightly in level.

The waters of the lake escape through the Oneida river—which by map measurement has a length of abo 16 miles—and, pursuing a crooked course between Oswego and Onondaga counties, unite with Seneca river at Th River Point. The elevation of the water surface of the lake is about 370 feet above mean sea-level, and 123 feet abo the average surface of lake Ontario. The fall to the mouth of the Oneida river is only about 8 feet, or an avera of say 0.5 foot per mile, and it is evident that the stream has substantially no value for power. Steam-towi navigation is carried on through the river between Syracuse and points on the lake, principally Constantia, Barnar Bay, Cleveland, and Fish Creek. Lumber, sand, and glass are carried down to Syracuse, and coal, feed, and flo returned.

The Oneida river is bordered by a flat country and has low banks. It runs about 300 feet wide at Caughden and 240 feet wide at Oak Orchard. Lowest water occurs in August and September, while in April or May th is a spring freshet, with an ordinary rise of 4 or 5 feet at Caughdenoy, and an extreme rise of 6 feet. The strean also subject to fluctuations due simply to the prevalence of a heavy east or west wind, which, at the locality j mentioned, sometimes amount to a foot in a few hours.

At Brewerton there are said to be rifts, but boats pass through them successfully in the channel. At Caughdenoy, a little village 4 miles by river below, is met the only use of power on the stream. The bed is there gravelly and causes rifts, around which boats pass in a canal a quarter of a mile long. The flow through the rifts is partially obstructed by a succession of 5 or 6 eel-weirs, built of vertical stakes against which are placed boards and piles of loose stone. As these serve to keep up the water-level above for navigation, the state has furnished much of the material for them. They raise the river but a few inches, and can have no very important effect upon the lake. A race perhaps 10 rods long conveys water from the canal to Hart's 4-run grist- and saw-mill. The head obtained is the same as the lift of the canal lock, ranging from 2½ to 3½ feet, according to the stage of water, but is commonly about 3 feet. Five water-wheels are employed, and can be run without trouble nine months in the year, and two or three can be run at all times. At Oak Orchard, 4 miles by river below Caughdenoy, the state has a dam, of horseshoe shape, over which there is a fall of perhaps 4 feet, boats passing through a lock at one side, but no power is utilized.

Drainage areas.

	Square miles.
Oneida creek	128
Chittenango creek	306
Fish creek	480
Oneida river at Brewerton, foot of lake	1,300
Oneida river at mouth	1,421

Cazenovia lake is described in French's *Gazetteer of New York* as "a beautiful sheet of water, 4 miles long, 900 feet above tide, and completely surrounded by gradually-sloping hill-sides". It is in the western part of Madison county, and discharges northward into Oneida lake through an outlet—Chittenango creek—which, following its meanderings, is by map measurement about 25½ miles long. The outlet of the lake is from the southern extremity, and there the state has a dam for controlling the storage. The flow over this dam, which is so placed, immediately below the lake outlet, as also to command the waters coming down Chittenango creek from above, including those of the Erieville reservoir,(*a*) passes down the natural channel of the creek for say 9½ miles, and is then diverted by a second state dam, through a feeder half a mile long, to the "long" level of the Erie canal. The fall from the lake to the feeder-dam is rapid and large, amounting to about 470 feet, and at Chittenango Falls, 3¾ miles below the foot of the lake, the stream suddenly plunges 136 feet over a limestone ledge. In the 16 miles, more or less, from the crest of the feeder-dam to Oneida lake, the descent is much less rapid, amounting to but 60 feet, and toward the mouth the course winds through low swampy land. The use of power along the creek is moderate in amount, and is principally confined to a half-dozen flouring- and grist-mills, three paper-mills, and several other establishments of small size.

According to a map of the middle division of the Erie canal with its feeders and reservoirs,(*b*) Cazenovia lake flows a surface area of about 2.8 square miles. Its available storage is placed at 4½ feet over an average area of 1,778 acres, or 348,523,560 cubic feet,(*c*) and the supply from the Chittenango Creek feeder, including the waters from both the Erieville and Cazenovia Lake reservoirs, at 42 cubic feet per second for 100 days.

Table showing the fall in Chittenango creek.

Locality.	Elevation above mean sea-level.	Fall between points.	Distance between points, by map measurement.	Authority for elevations.
	Feet.	*Feet.*	*Miles.*	
Cazenovia lake	900.00			French's *Gazetteer of New York*, page 22.
		469.53	9.5	
Crest of feeder-dam	430.47			Elevation assumed the same as that of the "long" level in the Erie canal, which by canal profiles is 428.4 feet above mean low tide at Albany.
		60.69	16.0	
Mouth of Chittenango creek	369.78			Level of Oneida lake as indicated by state canal profiles.

SENECA RIVER AND CONNECTING LAKES.

The Seneca river starts from the foot of the lake bearing the same name, and runs in an easterly direction to Cayuga lake, which it enters a mile or so from its northern extremity; issuing from that lake it flows northerly and then easterly, till at Three-River Point it joins the Oneida river to form the Oswego. By map measurement the total length of the stream from Seneca lake is about 60 miles. Until it reaches Cayuga lake it serves simply as an outlet to the waters of Seneca lake, receiving no accessions of importance from other sources. In this distance it falls 63 feet, the descent being nearly all concentrated at two points—Waterloo, where it amounts to 12 or 14 feet, and

a Storage, 21½ feet depth over an average area of 340 acres=318,423,600 cubic feet.
b Accompanying the *Annual Report of the Superintendent of Public Works* for the year ending September 30, 1881.
c Page 55, *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879.

Seneca Falls, where it is between 45 and 50 feet.(a) At both these places, and especially at the latter, the power furnished by the river sustains a large amount of manufacturing. North of Cayuga lake the river pursues its course among extensive marshes which have been partially drained by artificial means. It receives, successively, Clyde river from the west, and the outlets of Owasco, Skaneateles, and Onondaga lakes from the south. On the boundary between Onondaga and Cayuga counties it spreads out and itself forms Cross lake, some 4 miles long. In the 45 miles, more or less, of river below Cayuga lake the descent is only about 18 feet, and the only use of power is at Baldwinsville, where there is a state dam giving a fall of 8 or 9 feet. The Cayuga and Seneca canal starts from Geneva, at the foot of Seneca lake, and, utilizing the outlet for slack-water navigation except at the falls, descends toward Cayuga lake; before reaching the latter it strikes off to the left, and, crossing to the east side of the river below the lake, continues as an independent canal to Montezuma, where it joins the Erie canal. On Seneca river itself navigation in the lower course is maintained by a side cut around the Baldwinsville dam, and another across the bend at Jack's reefs, a short distance east of Cross lake.

The first dam below Seneca lake is at Waterloo, a village of about 3,900 inhabitants, where the use of hydraulic power dates back to the early part of the century. The state has a low dam of timber here, the navigation canal descending the north bank, while a hydraulic race about 25 feet wide runs down the south bank. Water is drawn by mills from this level through both the canal and the race, and in three cases directly from the pool above the dam. The interests of navigation, of course, take precedence, and if there is a scarcity of water for passing boats the mills must shut down until the level is sufficiently raised. Two or three years ago there was more or less shortage of water during a period of six months. The principal manufacturing concern is the Waterloo Woolen Manufacturing Company, located on the line of the navigation canal in the lower part of the village. Its production comprises shawls and ladies' suitings, and 20 sets of machinery are operated. Water is conveyed to the mills through a branch from the canal, 600 or 800 feet long, which also supplies a saw-mill. The other establishments using water from the level created by the state dam include 5 flouring- and grist-mills with an aggregate of 8 runs of stone and 17 sets of rollers, a saw-mill, and a small organ factory. In the vicinity of the dam a fall of about 9 feet is obtained at the various mills, increasing to 12 feet at the woolen-mill.

Half or three-quarters of a mile below the state dam is a private dam, a low, rude, and very leaky structure running out from each bank to an island. A race runs down the latter to a distillery, and on the north main bank there is a turning-shop and a wagon-wheel factory. The fall realized is only about 3 feet, steam is mainly employed, and the water-power has but little attention.

Seneca Falls, 3 miles below Waterloo, is an important manufacturing village of 5,900 inhabitants. The river is there 70 or 80 feet wide where running freely, and in the four falls occurring at the village descends from 45 to 50 feet. Canal-boats make the passage in a canal which follows down the right bank. The demands for lockage and the naturally lessened supply of water in the summer season cause a shortage for manufacturing purposes, commonly lasting for from 2 to 4 months, but which has continued in at least one exceptional instance for 6 months. The land bordering the stream is quite closely built up, except at the lowest fall, and there the power, though unemployed, is not large.

Water for manufacturing purposes enters the upper level over a stone weir, which is simply a continuation across the stream of the river-wall of the navigation canal, and is confined below the weir by a dam a short distance down stream, its crest perhaps a foot lower than that of the weir. By this means an undue drawing down of the upper pool is prevented. On the south bank are the large Phœnix woolen-mills, now idle. They are entitled to half the surplus flow of the river above the needs of navigation, receive it, when in operation, over a weir wall acting in the same manner as the one already noticed, and discharge tail-water back into the stream under the navigation canal, which runs between. On the north bank are half a dozen establishments of small and moderate size, located opposite the basin which is formed between the weir first described and the dam, and discharging into a covered tail-race which runs along under them and empties just below the dam. The heads actually in use range from 6 or 8 up to 15 feet, which may be considered as about the full fall of the privilege.

A dam 300 feet farther down stream creates the second level, from which water is drawn on the north bank for several small printing-press and other powers; and on the south bank, through a race, to supply a flouring-mill and three other important manufacturing concerns. The falls used on this level are from 12 to 14 feet.

For the third level, water is diverted by a low dam into a race on the north bank, which it enters over a stone weir. On this race are several mills and shops, of which the Silsby works are the largest, and falls ranging from 8 to 10 feet are obtained. The waste over the dam joins the navigation canal, and the basin thus formed is confined farther down by a spill-way, the overflow of which descends into the fourth level. All the land on the south bank opposite the third fall, securing half the flow of the stream, is owned by Mr. John A. Rumsey. The only use of power, however, on that side is by Rumsey & Co., who draw their supply from the navigation canal.

For the fourth level, the dam, in the pool of which the navigation canal crosses, has a fall of perhaps 2½ feet without or 4½ feet with flash-boards such as were found in place, but no power is utilized.

a The fall at these points could not be learned with accuracy, but the figures given are considered to be very near the truth.

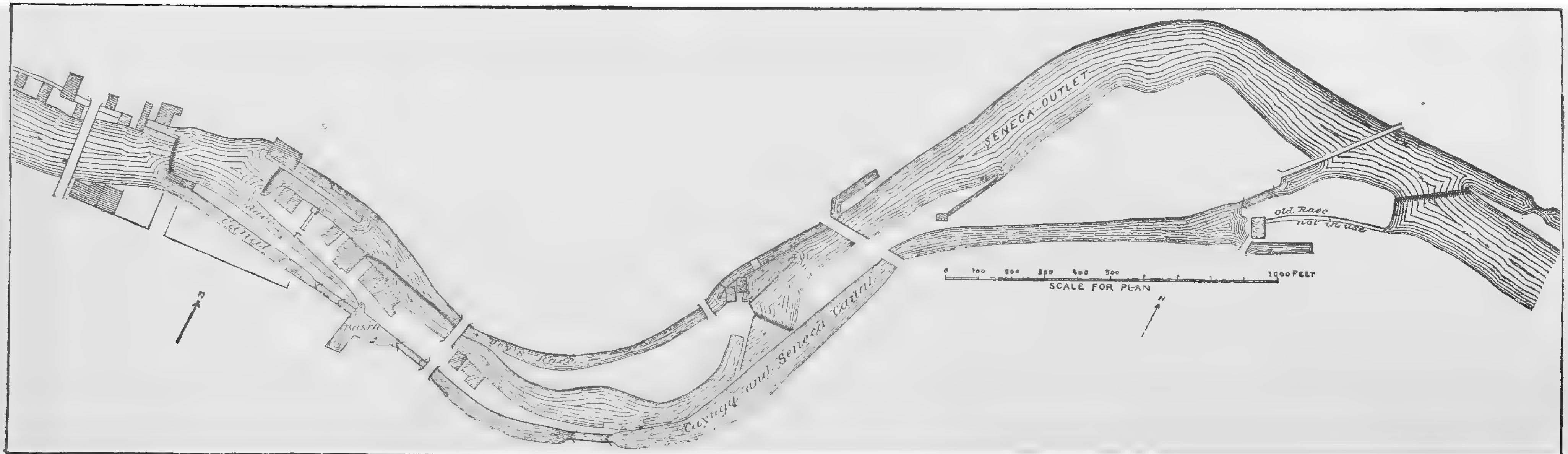

Fig. 6.—Plan showing water-privileges at Seneca Falls.

Data concerning manufacturing by water-power at Seneca Falls.

Level.	Firm.	Kind of mill or manufacture.	Remarks.
First or upper level	Phœnix Mills	Woolen goods	Large mill; not running.
Do	City Mills	Wooden ware	Employ 30 hands.
Do	Shoemaker, Daniels, & Co	Flouring- and custom-mill	4 runs of stone.
Do	Westcott Brothers	Table-mats	Employ 18 hands.
Do		Two small saw-mills and an advertising concern.	
Second level	Cowing & Gleason Manufacturing Company.	Pumps and other iron goods	Uses 3 wheels of about 40 horse-power each.
Do	Gleason Knitting Company	Knit underwear	20 sets of machinery.
Do	Roberts & Briggs	Flouring-mill	3 runs of stone, 6 sets of rollers; 80 barrels, daily production.
Do	Goulds Manufacturing Company	Iron pumps and hydraulic machinery	Employs from 275 to 300 hands; uses from 14 to 16 tons of iron per day.
Do	Several small powers used on the north bank.		
Third level	Silsby Manufacturing Company	Steam fire-engines, hose-carriages, and force-pumps.	Employs about 200 hands.
Do	Seneca Manufacturing Company	Scroll-saws, vises, and mill-castings	Employs 25 hands.
Do	J. F. Dalrymple	Custom- and flouring-mill	4 runs of stone.
Do	Charles Chamberlain	Flouring-mill	6 runs of stone.
Do	Rumsey & Co	Pumping- and fire-engines	Value of annual production, from $200,000 to $400,000.

There yet remains considerable available power at this point. On the upper level, as has been noticed, is the large Phœnix woolen-mill privilege, not in use; and on the opposite side of the river is a good site where a mill was burned. At the second fall it is possible that small powers could be rented in the block on the north bank. On the third level an important power belonging to Mr. Rumsey can be utilized for manufacturing, and the fourth or last fall in the village is entirely unimproved.

Estimate of power at Waterloo and Seneca Falls.

Locality.	Drainage area.	Assumed fall.	Assumed flow per second, average for the 24 hours, ordinary low stage. (a)	Theoretical horse-power. Per foot fall.	Theoretical horse-power. Total fall.	Effective horse-power of wheels in use.
	Sq. miles.	*Feet.*	*Cubic feet.*			
Waterloo	745	12	275	31.2	374	758
Seneca Falls	771	49	275	31.2	1,529	1,090

a No record of actual measurements of the volume is found, but on page 68 of the *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879, the supply available from Seneca lake is stated at 300 cubic feet per second, which it is judged may safely be relied upon throughout the greater part, if not the whole, of an average year. Allowing as much as 25 cubic feet per second for lockage, there will remain say 275 cubic feet available for power. For 9 or 10 months in the year a considerably larger discharge would doubtless be available.

The only other use of power on the entire river is at Baldwinsville, a place having a population of 2,100, and located about 12 miles from the mouth. The stream is there 250 feet wide, with gravelly bed and rather low banks. The dam runs across straight, with the exception of an offset up stream next the right bank. It is owned by the state, and is a crib-work structure, with stone filling, the face and back slope planked. The fall over it is 8 or 9 feet, without flash-boards, and about that amount of head is obtained at most of the mills. On the right bank, water for power is conveyed in a race 50 or 60 feet wide. The privilege along this race has hitherto been roughly subdivided into runs of stone and saws, but in the fall of 1882 a friendly suit was in progress to determine accurately the amounts of water belonging to the various owners. On the left bank the side-cut for boats passes around the dam and rifts, and all the mills, with one exception, draw water from it and discharge into the river.

Data concerning manufacturing by water-power at Baldwinsville.

Firm.	Kind of mill or manufacture.	Remarks.
On north race:		
Schoonmaker & Co	Straw wrapping-paper	
G. H. & A. T. Houghtaling	Flouring-mill	10 sets of rollers; capacity of mill, 200 barrels per day; 6 water-wheels, each of about 20 horse-power.
Clark, Mercer, & Co	Custom- and merchant-mill	5 runs of stone.
E. Allen	Wagon-shop	Employs 12 or 15 hands.
Draw from pond:		
Young & Frazee	Steel goods—forks, rakes, hoes, etc	Use 2 wheels, each of 25 horse-power; employ 25 hands, and manufacture 15,000 dozen articles per year.

Data concerning manufacturing by water-power at Baldwinsville—Continued.

Firm.	Kind of mill or manufacture.	Remarks.
Draw from canal side-cut:		
Frazee & Ducker	Saw- and planing-mill	4 circular saws.
J. C. Miller & Co.	Knit underwear	Run 7 sets of machinery and employ about 100 hands; 9 feet fall; 2 wheels, with aggregate of about 100 horse-power.
Jacob Amos & Sons	Flouring- and pearl-barley mill	4 runs of stone; 13 sets of rollers; capacity of mill, 250 barrels of flour per day; 12 feet fall; 8 wheels of 20 or 25 horse-power each.
James Frazee	Flouring-mill	14 sets of rollers.
William L. Wickins	Grist-mill	4 runs of stone.
Fuller & Bliss	Sashes, doors, and blinds	Employ 35 hands.
Heald & Morris	Pumps and engines	Employ 50 hands; transfer power 150 or 200 feet by cable from tower over wheel-pit.

Full advantage is not taken in all cases of the available fall, but with the present wheels and manner of development there is no opportunity for further obtaining permanent power. The state has the first right to water, and in low stages of the river the mills are frequently shut down temporarily, so as to bring up the level in the pool and canal and permit boats to pass. There was such a stoppage at the time this privilege was visited, December 1, 1882, and for two months during the summer more or less trouble is generally experienced by the mills, owing to a scarcity of water. Anchor-ice sometimes clogs the river below, raising the level at this point, and on one occasion has brought it up to the top of the dam. Spring high-water also causes some annoyance by reducing the head at the mills.

Estimate of power at Baldwinsville.

Stage of river.	Rainfall on basin. Spring.	Summer.	Autumn.	Winter.	Year.	Drainage area, gross.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 foot fall.	9 feet fall.	Effective horse-power of wheels in use.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year							800	90.9	820	
Low water, average year	8½	9½	9	6½	33½	*a* 3,136	1,000	113.6	1,020	953+
Available 10 months, average year							1,500	170.4	1,530	

a Of which about 376 square miles is more or less completely utilized in the dry season for feeding the Erie canal.

Seneca lake.—This beautiful sheet of water lies between the counties of Seneca on the east, and Ontario and Yates on the west, and at the southern extremity projects half-way across Schuyler county. As shown on French's map, it is 34 miles long and varies in width from 1 mile to 2½ miles. It has a surface area of about 66 square miles, and a total drainage area above its outlet of 707 square miles. Of this area, 94 square miles belongs to Catharine's creek, which empties at the head of the lake, and 213 square miles to Keuka lake and outlet. Seneca lake is 196½ feet above lake Ontario, and 443 feet above sea-level. The surface is 2 feet lower than formerly, having been artificially reduced in level by that amount years ago. The ordinary range between high and low water is from 2 to 2½ feet, with an extreme of 4 or 5 feet. Temporary oscillations, amounting to perhaps a foot or two, are also occasioned by unusually strong winds blowing up or down the lake. A gentleman long familiar with both Seneca and Cayuga lakes states that he has frequently observed strong currents setting sometimes up their courses and sometimes down, and even in opposite directions at one time on different sides of the same lake. A tidal oscillation is also claimed for this lake, and Mr. Franklin Gage, of Waterloo, a gentleman whose duties in connection with the Cayuga and Seneca canal have led to long-continued and careful observations of the lake-level, confidently maintains that there is a tidal rise of about 6 inches, and states that it has been found impossible to run a line of levels from the lake to the Waterloo dam and check successfully, without making allowance for the change of surface going on during the leveling. It is not to be doubted that there may be a frequent, and even for considerable periods a regular, ebb and flow in the lake waters, but it is hardly to be conceived that there should be an appreciable tide, properly so called; and it seems not improbable that the explanation of the changes of level may lie in the fact, which has been observed, that, during portions of the year at least, there is commonly a south wind on the lake in the forenoon and a north wind in the afternoon.

The scenery upon this lake and from the surrounding heights is most charming. At the northern end the banks are comparatively low, but advancing southward they become high and steep; thence eastward from the lake there is a gradual rise by smooth fertile slopes to the summit of a ridge which separates Seneca and Cayuga lakes, and which near their head attains an altitude of 700 or 800 feet above the water. The lake is thus seen to occupy a long, narrow, and deep depression among the hills, the depth of which would appear twice as great were the water removed. The bottom is said to be composed of gravel and rock, while the sides are frequently precipitous masses of solid rock. In 1880 an accurate survey of the lake by the engineering students of Cornell university was in progress, and by the kindness of Professor C. L. Crandall the following results of soundings were furnished to the author:

Depths of Seneca lake.

	Feet.
Four miles south of Geneva	250
Eight miles south of Geneva (off Dey's Landing)	430
Twelve miles south of Geneva (off Dresden, or opposite the inlet from Keuka lake)	500
Eighteen miles south of Geneva (off Lodi Landing)	580

The lake is navigable throughout the year, for it is only in remarkably cold seasons that it even becomes skimmed over with ice, except near the foot, and there it freezes but slightly. Canal-boats descend from Elmira through the Chemung canal and are towed down the lake by steam-tugs to Geneva, where they connect with the Cayuga and Seneca canal.

Drainage areas—Seneca lake and river.

	Square miles.		Square miles.
Catharine's creek at entrance into lake	94	Seneca river below Cayuga lake	1,593
Keuka lake and outlet	213	Seneca river at Montezuma	2,472
Total at head of Seneca outlet or river	707	Seneca river at Jack's reefs	3,080
Seneca river at Waterloo	745	Seneca river at Baldwinsville	3,136
Seneca river at Seneca Falls	771	Seneca river at junction with Oneida river	3,447
Seneca river at entrance to Cayuga lake	780		

Keuka or *Crooked lake*(*a*) lies a little to the westward of Seneca lake, with which it is connected by an outlet 6 or 8 miles long, having a fall of 277 feet. There is a dam at the head of this outlet, and the course of the latter was formerly followed by the Crooked Lake canal; but this has been abandoned, and navigation is now confined to the lake, where in 1880 five steamers were engaged in carrying passengers during the summer, and also in transporting a considerable amount of freight, consisting mainly of wine and grapes, which are largely produced upon the banks.

Keuka lake has an extreme length, measured from Penn Yan to Hammondsport, of 19¼ miles, and varies in general in width from half a mile to nearly a mile and a quarter. On the west, from somewhat south of the middle part of its course, an arm extends 14 miles due north. The area of water-surface is about 20 square miles, the drainage area at the head of the outlet is 187 square miles, and at the point where the outlet enters Seneca lake it is 213 square miles. The shores of the lake are abrupt and hilly, being low only near its foot. The surrounding country rises from 500 to 800 feet above the water-surface, and is quite bare of timber, though once well wooded. At the point where the two northern branches of the lake come together a bluff rises steeply, and attaining a height of 400 feet is continued northward in a ridge. The lake bottom has generally the character of a deposit, but in the deeper portions is thought to be composed of rock; it has quite an even grade, with few abrupt descents. As stated by Mr. George R. Youngs, of Penn Yan, who has devoted much study and observation to Keuka lake, the depth gradually increases from the foot, and at a distance of three-quarters of a mile is about 40 feet; at a distance of 1 mile, 100 feet; and for a distance of from 1½ mile to 12 miles, about 140 feet. Along the west branch the depth ranges from 200 to 250 feet, and from Bluff Point, where the branches unite, to the head of the lake, about 7½ miles, the average depth is more than 200 feet.

This lake is 473½ feet above lake Ontario and 720 feet above ocean-level. Its surface is but little affected in elevation by continued strong winds, and no phenomena of the nature of tides, such as are claimed for Seneca and Skaneateles lakes, have ever been observed, so far as known. There is an annual variation from high to low water of 5 or 6 feet, and the very unusual range of 9 feet has been recorded. High water is reached in April, or occasionally later, while the lowest stage is generally attained in December. Unlike Seneca and Cayuga lakes, Keuka lake commonly freezes over in winter.

According to the enumerators' returns, the use of water-power on the outlet was in 1880 confined to six flouring and grist-mills, employing an aggregate fall of 63½ feet and 420 horse-power of wheels. An estimate is given below of the theoretical power for the entire fall in the outlet, based upon the assumed average discharge from the lake:

Estimated power of Keuka outlet.

Assumed stage of water.	Rainfall on basin.					Drainage area at head of outlet.	Mean flow for the year per second, average for the 24 hours. (*b*)	Theoretical horse-power. (*c*)		Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*277 feet fall.*	
Average discharge in a series of years	7½	9½	8	5½	30½	187	190	21.58	5,980	420

a For much of the general information concerning this lake thanks are due to Mr. F. M. Collin, of Penn Yan.

b Of course this assumption can not be realized—*i. e.*, the flow maintained with uniformity throughout the year—unless there is a proper control exercised at the outlet; otherwise the natural discharge will gradually decline from spring till winter, being part of the year probably above, and part below, the amount here estimated. By concentration within 12 hours per day the flow could be doubled.

c With good wheels, from 60 to 80 per cent. of the theoretical power is available for work.

Cayuga lake lies some 10 miles to the eastward of Seneca lake, to which it bears a strong resemblance, and is at an elevation 63 feet less, or, in other words, 133½ feet above lake Ontario and 380 feet above mean sea-level. Aside from Seneca river, which empties into it near the foot, its principal tributary streams are Cayuga inlet and Fall creek at its head, Salmon creek on the east, and Taughanick creek on the west. The total drainage area of the lake at its foot, independent of Seneca river, is 813 square miles. The lake is utilized for steam-towing navigation, and in the deeper portion, including the greater part of its surface, is always free from ice; but the shallow section, extending 9 or 10 miles from the foot, is regularly frozen over as far as between Springport and Aurora. The ordinary change in level from low to high water is 3 feet, with an extreme range of 7 feet. Near the outlet the banks are low, but ascending the lake they grow abrupt and rocky, and are succeeded by easy but continuous ascents, cleared and cultivated, to the summits of hills several hundred feet in height above the water.

Cayuga lake has been carefully triangulated, sounded, and mapped by the engineering students of Cornell university. From the data thus obtained it appears that the lake has a length of about 37½ miles, and a width of from a mile to a mile and a quarter near the head, increasing in the widest part, opposite Aurora, two-thirds of the way down its course, to very nearly 3½ miles. The area of its surface is 66¾ square miles. The greatest depth obtained by soundings was 435 feet, 15½ miles from the head. Following down the center line of the lake the depth is at first shallow, not exceeding about 25 feet for the first mile; it then increases rapidly and reaches 200 feet at 1¾ mile from the head, 300 feet at 3¼ miles, and 400 feet at 6½ miles; it then ranges between 350 and 435 feet for the succeeding 16 miles. Opposite Aurora the depth is still from 300 to 340 feet toward the west shore, but in the next 5 miles rapidly decreases to 100 feet or less, and in the remaining 9 or 10 miles to the outlet is under 50 feet, and most of the way under 20 feet. Depths of from 50 to 100 feet, and even more, are common close to the shores in the upper part of the lake, and soundings of 200 and 300 feet and upward are recorded within 1,000 or 1,500 feet of the shores.

Drainage areas—Cayuga lake and tributaries.

	Square miles.
Taughanick creek at mouth	60
Salmon creek at mouth	90
Fall creek, not including Cascadilla creek	152
Cayuga inlet, including Cascadilla creek	173
Total, Cayuga lake at outlet, not including Seneca river	813
Total, Cayuga lake at outlet, including Seneca river	1,593

Canandaigua lake lies mainly in Ontario county, though bordering partly on Yates. It is about 15 miles long, and 1⅝ mile wide in the broadest part. The surface area is between 18 and 19 square miles, and the drainage area at the head of the outlet is 175 square miles. The principal tributary stream is Canandaigua inlet, draining 85 square miles. There is no marshy land along this lake. The shores are generally succeeded by a uniform rise to high hills, but toward the head of the lake become frequently abrupt and rocky. The surrounding country is rich farming land, and at the upper end of the lake there is considerable timber. The water depth is rather shallow toward the head and foot, ranging say from 10 to 30 feet, but a gentleman well acquainted with the lake estimated it to be elsewhere as great as 150 feet. The bed is variously composed of clay, gravel, and rock, and has usually a gradual slope, though there are in places very steep pitches. The surface commonly freezes over in part only. There is no canal-boat navigation upon or in connection with this lake, but some freight is transported over it in steamers. The altitude of the water-surface is given in French's *Gazetteer* and elsewhere as 668 feet above tide, but by the profile of the Northern Central railroad, which crosses the outlet at Canandaigua, ordinary low water in the stream is 687.5 feet above mean ocean-level, and in the absence of other data the lake-surface may be assumed to have at least that elevation.

Table showing approximately the fall in Canandaigua outlet and Clyde river.

Locality.	Elevation of water-surface above mean sea-level.	Distance between points, by map measurement.	Fall between points.	Remarks.
	Feet.	*Miles.*	*Feet.*	
Canandaigua lake	687.5			Elevation assumed to be the same as in outlet at Northern Central Railroad crossing.
Canandaigua outlet at head, where crossed by Northern Central railroad.	687.5	26	287.5	Ordinary low water, by Northern Central Railroad profile.
Canandaigua outlet at Lyons (mouth).	400.0	22	20.0	400 feet assumed as approximately correct. The New York Central and Hudson River railroad crosses near the mouth, and the rails are stated to be 410 feet above sea-level.
Clyde river at mouth	380.0			Elevation assumed to be the same as that of Cayuga lake.

The Canandaigua outlet pursues a winding course, first to the northward, then to the eastward, and then northerly again, to Lyons, descending in the interval about 287 feet, and passing successively through the towns of Canandaigua, Hopewell, Manchester, Phelps, and Lyons. It has a length of about 30 miles by map measurement, and at the village of Lyons unites with Mud creek, which drains a section to the westward, to form the Clyde river. The latter flows with a general southeasterly trend, including two right-angled bends, for a distance by river of at least 22 miles, and unites with the Seneca river 3 miles below the foot of Cayuga lake. Its slope is small, the entire descent from Lyons amounting to but about 20 feet. Manufacturing by water-power is carried on at various points along Canandaigua outlet, more especially in the towns of Manchester and Phelps, where there are numerous flouring-, grist-, and saw-mills, and establishments for making agricultural implements, carriage and wagon materials, paper, and fertilizers. At other localities along the stream the principal use of power is by flouring- and grist-mills.

Estimated power per foot of fall at head of Canandaigua outlet.

Assumed stage of water.	Rainfall on basin.					Drainage area.	Mean flow for the year per second, average for the 24 hours. (a)	Corresponding theoretical horse-power per foot of fall.
	Spring.	Summer.	Autumn.	Winter.	Year.			
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	
Average discharge in a series of years	9	10	9	7½	35½	175	210	23.86

a In practice the flow could be maintained uniformly at this figure only by a suitable control at the outlet from the lake; otherwise there would be a gradual decline during the year from a higher to a lower discharge than here given. Of course, for twelve hours in the day the flow could be doubled from the estimate given, assuming that to be correct.

Drainage areas—Clyde river and tributaries.

	Square miles.
Canandaigua inlet	85
Canandaigua lake at head of outlet	175
Canandaigua outlet at Manchester	211
Canandaigua outlet at Phelps	390
Canandaigua outlet at Lyons, mouth of outlet	431
Mud creek at Lyons	298
Clyde river at Lyons, junction of Canandaigua outlet and Mud creek	729
Clyde river at Clyde	807
Clyde river at mouth	869

Owasco lake lies in the southern part of Cayuga county, and discharges northward through an outlet 15 miles long to Seneca river. It has a length of 11¼ miles, a width of nearly a mile and a half in the broadest part, and flows an area of about 12.4 square miles. At the head it receives Owasco inlet, draining 120 square miles, and itself commands, at the head of the outlet and including its own surface, a tributary area of about 208 square miles. The country bordering the foot of the lake is flat, while elsewhere the immediate shores generally display a narrow strip of level land, succeeded by an easy uniform slope upward to highlands, rising toward the head of the lake from 1,000 to 1,200 feet above tide, though in places precipitous bluffs approach close to the water. This region has been mainly denuded of its timber, but has a fertile soil and is well suited either to the raising of grains or to pasturage.

The bottom of the lake is largely covered with sand and the shores are gravelly. The water is shallow toward the head and foot, but attains considerable depth elsewhere, though no information was gained of any soundings. Its supply is derived in part from the surface-drainage of its basin, and also in large part from springs, which may extend the effective drainage area beyond the limits which are apparent on the surface. Thus there is a common belief, though it is uncertain what special foundation exists for it, that there is an underground connection between Owasco and Cayuga lake, 8 or 10 miles westward.

Owasco lake freezes entirely over in winter, though not commonly until February, and remains closed into March. Thick ice usually forms in the outlet before the lake becomes frozen, but as soon as the latter freezes its waters seem to grow warmer and the ice in the outlet disappears, or, at the most, only a thin sheet remains. The surface of the lake was raised artificially years ago and the flowage increased by probably from 300 to 500 acres to the present amount. At the same time a new and much straighter channel was made for the outlet near the lake; but southerly storms have filled this considerably with sand, to the injury, it is said, of the powers along the stream below. The water-surface is subject to an annual variation of about 5 feet between high and low water. It is also liable to temporary changes in level of 6 or 8 inches, due to winds, and even of a foot or more in a short time when a north or south wind is followed by the opposite.

Table showing approximately the fall in Owasco outlet.

Locality.	Elevation above mean sea-level.	Fall between points.	Distance between points, map measurement.	Fall per mile between points.	Authority for elevation.
	Feet.	*Feet.*	*Miles.*	*Feet.*	
Owasco lake	707				Elevation as given by E. F. Swart, chief engineer of Southern Central railroad. Shown by an old survey.
		302	9.2	32.8	
Owasco outlet, crest of state feeder-dam	405				Elevation assumed the same as that of Port Byron level of Erie canal = 402.988 feet + mean low tide at Albany.
		15	2.8	5.4	
Owasco outlet, New York Central and Hudson River Railroad crossing below Port Byron.	390				New York Central and Hudson River Railroad profile. Elevation estimated from grade of track at crossing, elevation of latter being 402.06 feet.
		13	1.9	6.8	
Mouth of outlet	377				Estimated from elevation of Cayuga lake.

As shown in the foregoing table, there is a total descent of about 330 feet in the 14 miles from Owasco lake to the Seneca river. There are a number of small powers employed at Port Byron, but by far the most important use of the outlet is at the city of Auburn. This place is distant about 2½ miles from the foot of the lake, has a population of 22,000, and is the site of a large amount of manufacturing, partially supported by water-power. At the head of the outlet the state has a dam for controlling the storage of the lake. On the privilege thus developed there is a fall of 16 feet, and in a full stage of water 500 horse-power is utilized by the Auburn water-works; there is also a saw-mill on this fall entitled to four-ninths of the water. Passing down through the city there is a succession of dams, with usually two or three, and often more, establishments grouped around a single fall. Many of the concerns are of important size, and especially to be noticed are the extensive mowing- and reaping-machine works of Messrs. D. M. Osborne & Co., and the Auburn woolen-mill; the latter has a fall of 22 feet and a large pondage. Power is also employed at the state prison and at various mills and factories other than those already mentioned, the manufactures comprising a variety of agricultural implements, flour, woolen goods, tools, axles, scythes, wringers, carpets, starch, lumber, cast goods, patterns, sashes and blinds, and other articles.

There are numerous privileges where in high water there is more or less surplus power, but there is stated to be probably no unoccupied fall of importance at Auburn. Although some of the manufacturing concerns on the stream at this locality are very extensive, they invariably rely largely upon steam for motive power, and it is estimated that, in general, full capacity of the wheels in place can be realized only five or six months in the year.

The available storage of Owasco lake is estimated at 1,481,040,000 cubic feet.(*a*) Some 7 miles below Auburn the state has a second dam across the outlet, and through a feeder 4 miles or more in length so much of the water as is needed is conveyed to the Port Byron level of the Erie canal, the latter crossing the outlet on an aqueduct. The supply of water obtained in this manner, average for an assumed period of 220 days of canal navigation, is estimated as about 100 cubic feet per second,(*b*) as follows:

	Cubic feet per second.
Owasco Creek feeder, natural flow	67
Owasco Lake reservoir	33

It is stated, however, that an increased supply can readily be obtained from the lake, as a large surplus now wastes over the Port Byron feeder-dam.

Drainage areas—Owasco outlet.

	Square miles.
Owasco inlet	120
Owasco lake at head of outlet	208
Owasco outlet at Auburn	212
Owasco outlet at mouth	230

Skaneateles lake lies in the southwestern part of Onondaga county, bordering for about one-half its length upon Cayuga county to the westward. It has a length varying, according to different authorities, from about 13 to between 15 and 16 miles, and an extreme width of from 1¼ to 1½ mile. As shown on French's map of New York state, the flowage is a little over 15 square miles, or say from 9,600 to 9,700 acres. The drainage area at the foot of the lake, or head of the outlet, is 84 square miles, including the lake-surface, and 117 square miles at the mouth of the outlet. The altitude of the lake is stated as 860¼ feet above tide.(*c*) Its drainage basin is quite contracted, the water-shed line seldom departing more than a mile and a half from the banks, except southeast of the head of the lake, where it recedes to a distance of nearly 5 miles. There is no marshy land bordering the lake; on the

a Five feet depth on a mean area of 6,800 acres. See page 55, *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879.

b Sub-report by Marvin Porter, division engineer, page 92 of above report by state engineer.

c French's *Gazetteer of New York*, page 487.

contrary, there is a steady rise to high hills, and toward the southern extremity the banks ascend precipitously several hundred feet, forming very wild and beautiful scenery. The adjoining land is well suited to farming on the west shore for say 7 miles from the foot and on the east to within 4 miles of the head of the lake. A moderate amount of timber is yet standing in this section.

Much of the supply of Skaneateles lake is derived from hidden springs, and its waters are very clear and pure. The surface freezes over by the middle of January, and remains frozen until April. The depth near the outlet is small, ranging from 10 to 30 feet, perhaps, but the bottom then suddenly falls away 50 feet or more. The greatest depth is found south of Borodino, which is about half way up the lake, the deepest sounding being 320 feet. The same phenomenon is noticed here which has been mentioned in connection with Seneca lake. Mr. S. D. Conover, of Skaneateles, who has for years regularly recorded the level of the lake, is firmly convinced, and states it as the general opinion among people in this vicinity, that the lake is subject to tides like those in the ocean. They occur throughout the year, and the time of high tide varies from day to day; but whether or not it varies according to any uniform law, Mr. Conover was unable to say. He considers that these movements can not be due to winds, for they are noticeable when there is no wind, and he has himself observed a change of 4 inches in level in a perfectly calm day. Besides these regularly-recurring oscillations there are others, plainly due to storms and wind. The lake has been known to recede 9 inches in an hour, after a heavy thunder-storm, and there are sometimes several changes or pulsations in an hour.

The following table shows the highest and lowest water levels in each year from 1870 to 1880, referred to extreme high-water mark. In 1878 there was a rise of level of 1½ inch after a three days' rain. In 1877, from March 9 to March 13, the lake rose 7 inches; and from March 13 to April 3 it rose 13 inches. In general, lowest water is reached toward the close of the year, while the highest stage occurs in spring or early summer:

Record of high and low water in Skaneateles lake, during each year from 1870 *to* 1880, *as kept by Mr. S. D. Conover, of Skaneateles village.*

[Levels are referred to extreme high water=zero.]

Year.	High water.			Low water.			Year.	High water.			Low water.		
		Ft.	*In.*		*Ft.*	*In.*			*Ft.*	*In.*		*Ft.*	*In.*
1870	May 23	0	0	December 5	—4	6½	1875	April 22	—2	2	December 22	—5	4½
1871	May 10	—3	2½	February 21	—5	7	1876	June 26	—0	4	December 19	—3	8½
				November 15	—6	6¾	1877	April 30	—1	3	December 14	—5	0
1872	June 27	—3	6½	February 24	—7	0	1878	May 6	—2	2½	November 18	—4	7½
1873	May 12	—0	6¼	March 17	—4	11	1879	May 8	—0	3½	December 1	—3	6
1874	July 1	0	0	December 29	—3	6	1880	April 20	—2	5	October *a* 11	—4	11

a Last record obtained.

The surplus waters of the lake are discharged through Skaneateles creek or outlet, running about 13 miles northward to the Seneca river and lying mainly in the towns of Skaneateles and Elbridge. The fall from the lake to Seneca river is in the neighborhood of 485 feet, and with the supply of water at command gives a steady, and, in the aggregate, important amount of power, which already has been largely put to use. In 1880 there were above Skaneateles Junction, which is between 5 and 6 miles from the lake, 3 flouring- and grist-mills, 4 paper-mills, 2 woolen-mills, and a vacant site where another had been burned, a chair factory, a rolling-mill (not in operation), a pulp-mill, a machine-shop and foundery, an establishment for making water-lime, and a distillery; besides numerous mills and shops farther down the stream, for the manufacture of flour, machinery, paper, and various articles in wood.

There yet remain many unimproved sites along the outlet, which it is the general desire to see developed, and which are said to be held at very reasonable prices. The locality is convenient of access, and on account of the small size and rocky bed of the outlet, and the steady flow and immunity from freshets secured by the lake, the privileges may be securely and yet cheaply improved. The Skaneateles railroad follows the outlet about half way down its course, from the foot of the lake to the New York Central railroad (Auburn line), and the direct line of the latter road also crosses the stream between 1 and 2 miles from its mouth.

The waters of the lake and outlet, besides being employed for power in manufacturing, are utilized by the state for feeding the Erie canal. In order to control the storage in the lake a dam is maintained at the head of the outlet. The flow over this dam passes down the natural channel of the stream, being used at the mills on its way, and about 2½ miles from the mouth is diverted by a second state dam into a short feeder running to the Jordan level of the Erie canal. The state could so regulate the flow from the lake as to shut off for a time the supply from the mills; it is not done, however, in practice, and if it were, a liability for damages would be created, it is claimed, as the manufacturers consider that they are entitled to the benefit of the natural flow. It is stated that the lake can be drawn down as much as 8 feet from extreme high-water line, but the common estimate of available

storage for canal purposes is a depth of 6 feet for an average area of 8,320 acres, or 2,174,515,200 cubic feet.(*a*) The supply that may be relied upon from this lake and outlet for a period of 120 days is reckoned as about 146 cubic feet per second. (*b*)

Table showing the fall in Skaneateles creek.

Locality.	Elevation above mean sea-level.	Fall between points.	Distance between points, by map measurement.	Authority for elevation.
	Feet.	*Feet.*	*Miles.*	
Skaneateles lake	860.25			French's *Gazetteer of New York.*
		449.61	11.7	
Crest of feeder dam	410.64			Elevation assumed the same as that of Jordan level of Erie canal = 408.568 feet + mean low tide at Albany.
		28.64		
Water-surface at Jordan crossing of New York Central railroad	382.00		1.5	Elevation estimated from New York Central Railroad profile, grade of track at crossing being 392.07 feet + ocean-level.
		7.00		
Mouth of creek	375.00			Elevation estimated from that of Cayuga lake.

Onondaga lake lies in the northern central part of Onondaga county, immediately to the northwest of Syracuse, and empties northward into Seneca river through a state ditch less than half a mile long. It has a surface of approximately 4.1 square miles, an extreme length of between 4 and 4½ miles, and is perhaps 1¼ mile wide in the broadest part. The principal tributaries are Onondaga creek, draining 118 square miles, and Nine-Mile creek, 100 square miles; while the total area of the drainage basin above the foot of the lake is 267 square miles. The elevation of the lake is variously given as 361 (*c*) and 369 (*d*) feet above tide, and the greatest depth is stated as 65 feet. The water is shallow for half a mile out from the shore, and then rapidly deepens.

As described by Mr. Gardner Van Uxem, this lake is "the remains of an ancient and deep excavation in the Onondaga salt group, of which Onondaga valley forms the southern part, all which has been filled up with sand, gravel, etc., except the part occupied by the lake. * * * The bottom of Onondaga lake and its sides are covered with lake marl, showing a thickness where bored of 6 and more feet". The famous salt springs of this locality are found in and about a marshy piece of ground which extends some 2 miles from the head of the lake. The shores of the latter are low, largely reclaimed land, but are succeeded farther back by a rise to high ground. The lake fills in spring, overflowing its borders, and then gradually declines in level through the year. So far as can be learned there is no power in use on the outlet, and no opportunity for any.

Otisco lake lies southwest of Onondaga lake and 2½ or 3 miles east of Skaneateles lake. It drains to the former of these through Nine-Mile creek, which really has a length, by map measurement, of about 18 miles. This creek has a fall of 361 feet to the Camillus feeder-dam, and a total of about 411 feet to the level of Onondaga lake. The power thus afforded is partially utilized by a considerable number of mills, embracing in their production flour, lumber, paper, powder, lime, and leather. As represented on a map of the middle division of the Erie canal, with its reservoirs and feeders, Otisco lake flows 4 square miles. In the *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879 (page 55), the storage is placed at 784,000,000 cubic feet. In the same report (page 92) the supply of water afforded is stated as about 116 cubic feet per second for 120 days, from the lake, in addition to which the natural flow of the outlet yields for feeding-purposes 13 cubic feet per second for 220 days; it is also stated that the lake has a drainage basin of 22,000 acres, and that by raising its surface 2 feet the supply from it can be further increased by 10 cubic feet per second.

Table showing the fall in Nine-Mile creek.

Locality.	Elevation above mean sea-level.	Fall between points.	Distance between points, by map measurement.	Authority for elevation.
	Feet.	*Feet.*	*Miles.*	
Otisco lake	772			French's *Gazetteer of New York*, p. 486.
		361	11.4	
Crest of feeder-dam	411			Elevation assumed the same as that of Jordan level of Erie canal, = 408.568 feet + mean low tide at Albany, or 410.64 feet + mean sea-level.
		50	6.7	
Onondaga lake	361			French's *Gazetteer of New York*, p. 22.

a See sub-report by Marvin Porter, division engineer, page 55 of *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879.

b Page 92, report last referred to.

c French's *Gazetteer of New York*, page 22.

d *Notes upon the Geological History of Cayuga and Seneca Lakes*, by Charles W. Foote, A. M.

The state has a dam at the foot of the lake for controlling its storage; the discharge over this passes down the natural channel of Nine-Mile creek, and between 11 and 12 miles down stream, at Camillus, is by a second dam turned into a feeder running a mile and a half to the Jordan level of the Erie canal.

Table of utilized power on the Oswego river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Oswego river	Lake Ontario	New York	Oswego	Blacksmith-shop	1	Total of six utilized falls on the Oswego river, about 80 feet.	16		
Do	do	do	do	Cement	1		25		
Do	do	do	do	Cigar-boxes	1				
Do	do	do	do	Coffins and burial-cases	1				
Do	do	do	do	Cutlery and edge-tools	1		40		
Do	do	do	do	Dry-dock	1				
Do	do	do	do	Elevators (grain)	4				Not including those in connection with mills.
Do	do	do	do	Flouring and grist	15		1,939		
Do	do	do	do	Flux	1		25		
Do	do	do	do	Hardware	1		15		
Do	do	do	do	Hosiery	1		70		
Do	do	do	do	Machine-shops and founderies.	3		233		
Do	do	do	do	Malt	3		40+		
Do	do	do	do	Paper (including wood-pulp).	4		330+		
Do	do	do	do	Planing	3		140		
Do	do	do	do	Plaster	2		75		
Do	do	do	do	Printing and publishing	1		8		
Do	do	do	do	Pumping-works	1		200		Supply Oswego.
Do	do	do	do	Quarry	1				
Do	do	do	do	Sashes, doors, and blinds	1		10		
Do	do	do	do	Saw	4		156+		
Do	do	do	do	Starch	1		1,220	483	
Do	do	do	do	Tannery	1		65		
Do	do	do	do	Wheelwrighting	2		48		
Do	do	do	do	Window blinds and shades	2		120	80	
Do	do	do	do	Wooden packing-boxes	1		140		
Do	do	do	do	Wooden ware	1		30		
Do	do	do	do	Woolen	1		25		
Do	do	do	do	Worsted	1		1,270		
Do	do	do	Onondaga	Coffins and burial cases	1		50		
Do	do	do	do	Paper	1				
Oneida river	Oswego river	do	do	Flouring, grist, and saw	1	3	120		
Small tributaries	Oneida river	do	Oswego	Saw	4	40	92		
Canaseraga creek and tributaries.	Oneida lake	do	Madison	Fertilizers	1	9	25		Mills nearly all on tributaries.
Do	do	do	do	Flouring and grist	6	118	185	30	
Do	do	do	do	Saw	7	115½	124	25	
Chittenango creek and tributaries.	do	do	do	Cotton	1	13	60	60	Mills nearly all on main stream.
Do	do	do	do	Cutlery and edge-tools	1	9			
Do	do	do	do	Flouring and grist	8	129	294		
Do	do	do	do	Iron castings and finishings.	1	6	25		
Do	do	do	do	Paper	3	35	180		
Do	do	do	do	Saw	5	116	70		
Do	do	do	do	Sporting goods	1	4	6		
Do	do	do	do	Wheelbarrows	1	4	6		
Do	do	do	Onondaga	Agricultural implements	2	40	22		Mills all on tributary streams.
Do	do	do	do	Barley	1	12	30		
Do	do	do	do	Carpentering	1	6	10		
Do	do	do	do	Cement	1	8	100		
Do	do	do	do	Fertilizers	2	46	58		
Do	do	do	do	Flouring and grist	18	325½	631	45	
Do	do	do	do	Furniture	1	24	10		
Do	do	do	do	Hones and whetstones	1	17	90		
Do	do	do	do	Lumber, planed	1	9	10		
Do	do	do	do	Machinery	1	8	10		
Do	do	do	do	Paper	3	55	220		
Do	do	do	do	Sashes, doors, and blinds	2	29	70		

Table of utilized power on the Oswego river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Chittenango creek and tributaries.	Oneida lake	New York	Onondaga	Saw	16	258½	538		Mills all on tributary streams.
Do	do	do	do	Tannery	1	11	3	10	
Do	do	do	do	Wood, turned and carved	1	16	14		
Fish creek and tributaries.	do	do	Oneida	Agricultural implements	4	48	37		
Do	do	do	do	Flouring and grist	9	127½	358		
Do	do	do	do	Furniture	3	30	66	50	
Do	do	do	do	Hones and whetstones	1	9	50		
Do	do	do	do	Iron castings and finishings.	3	28	41		
Do	do	do	do	Machinery	1	11	15		
Do	do	do	do	Paper	1	5	30		
Do	do	do	do	Sashes, doors, and blinds	2	19	27		
Do	do	do	do	Saw	31	365	730	10	
Do	do	do	do	Tanneries	3	34	38	60	
Do	do	do	do	Wheelbarrows	1	6	5		
Do	do	do	do	Wooden packing-boxes	2	30	85		
Do	do	do	do	Wood-pulp	1	7	60		
Do	do	do	do	Wood, turned and carved	1	9	4		
Do	do	do	do	Wooden ware	1	13	14		
Do	do	do	do	Woolen	1	9	20		
Do	do	do	Oswego	Flouring and grist	1	16	25		
Do	do	do	do	Saw	9	106	237	40	
Do	do	do	Lewis	do	7	84½	246		
Oneida creek and tributaries.	do	do	Madison	Agricultural implements	1	10	30		Excepting silk-mill and one fertilizer factory, mills all on main stream.
Do	do	do	do	Fertilizers	2	24	30		
Do	do	do	do	Flouring and grist	7	144	363	70	
Do	do	do	do	Lime	1		10		
Do	do	do	do	Saw	5	69	83		
Do	do	do	do	Silk	1	23½	76	76	
Do	do	do	do	Wooden packing-boxes	1	12	10		
Do	do	do	Oneida	Agricultural implements	1	8	14		With two exceptions, mills all on tributary streams.
Do	do	do	do	Carpentering	1	11	24		
Do	do	do	do	Flouring and grist	5	66	385		
Do	do	do	do	Machinery	1		8		
Do	do	do	do	Saw	6	67	164		
Do	do	do	do	Surgical appliances	1	23½	18	65	
Do	do	do	do	Wooden packing-boxes	3	21+	62		
Do	do	do	do	Woolen	1	8	10		
Sundry small tributaries.	do	do	do	Butter and cheese	1	10	20		
Do	do	do	do	Flouring and grist	3	44	90		
Do	do	do	do	Saw	6	100	142		
Do	do	do	Oswego	Flouring and grist	5	62	185		
Do	do	do	do	Saw	22	262½	681		
Do	do	do	do	Tannery	1	15	40	75	
Seneca river	Oswego river	do	Seneca	Carriage and wagon materials.	1	Seneca Falls and Waterloo—total of utilized falls about 60 feet.	45	80	
Do	do	do	do	Cooperage	1		60		
Do	do	do	do	Distillery	1				
Do	do	do	do	Files	1		85		
Do	do	do	do	Flouring and grist	9		610		
Do	do	do	do	Iron castings and finishings.	1		20	10	
Do	do	do	do	Knit underwear	1		160		
Do	do	do	do	Lumber, planed	1		12		
Do	do	do	do	Machinery (including pumps).	5		300	95	
Do	do	do	do	Malt	2		27		
Do	do	do	do	Organs	1		20		
Do	do	do	do	Printing and publishing	3		60		
Do	do	do	do	Sashes, doors, and blinds	1		20		
Do	do	do	do	Saw	5		176	55	
Do	do	do	do	Table-mats	1				
Do	do	do	do	Wood, turned and carved	2		18		
Do	do	do	do	Woolen	1		175	200	

Table of utilized power on the Oswego river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Seneca river	Oswego river	New York	Onondaga	Agricultural implements	1	Baldwinsville—fall 9 feet.	50		
Do	do	do	do	Carriages and wagons	1		16		
Do	do	do	do	Fertilizers	1		20		
Do	do	do	do	Flouring and grist	5		690		
Do	do	do	do	Hosiery	1		100	30	
Do	do	do	do	Paper	1				
Do	do	do	do	Pumps	1		22		
Do	do	do	do	Sashes, doors, and blinds	1		25	25	
Do	do	do	do	Saw and planing	1		30		
Keuka outlet	Seneca lake	do	Yates	Flouring and grist	6	63½	420		
Sundry tributaries	Keuka lake	do	Steuben	do	1	19	40		
Do	do	do	do	Saw	1	25	25		
Do	do	do	do	Wooden packing-boxes	1	25	6		
Do	do	do	do	Woolen	1	32	17		
Do	Seneca lake	do	Cayuga	Fertilizers	1	12	20		
Do	do	do	Schuyler	do	1	115	40		
Do	do	do	do	Flouring and grist	7	299	246	80	
Do	do	do	do	Saw	6	97½	117	30	
Do	do	do	Seneca	Flouring and grist	1	40	40	20	
Do	do	do	Yates	do	5	226½	206	68	
Do	Cayuga lake	do	Cayuga	do	10	276	348	173	
Do	do	do	do	Saw	4	55	105		
Do	do	do	Cortland	do	1	6	15		
Do	do	do	do	Flouring and grist	1	22	27		
Do	do	do	Schuyler	do	1	22	45		
Do	do	do	do	Saw	5	38+	76		
Do	do	do	Seneca	Flouring and grist	4	121	99	10	
Do	do	do	do	Saw	1	12	18		
Do	do	do	do	Woolen	1	12	10		
Do	do	do	Tompkins	Agricultural implements	4	43	75	15	
Do	do	do	do	Carriage and wagon materials.	1	30	24		
Do	do	do	do	Cooperage	3	25	73		
Do	do	do	do	Fertilizers	2	48	70		
Do	do	do	do	Flouring and grist	29	613	1,325	110	
Do	do	do	do	Millwrighting	1	7	4		
Do	do	do	do	Paper	2	52	252	45	
Do	do	do	do	Sashes, doors, and blinds	1	16	10	15	
Do	do	do	do	Saw	20	269	602	15	
Do	do	do	do	Tannery	1	13	10		
Do	do	do	do	Woolen	4	47½	74	92	
Mud creek and tributaries.	Clyde river	do	Wayne	Flouring and grist	12	101	386	20	
Do	do	do	do	Saw	1	14	15		
Do	do	do	do	Woolen	1	4	16		
Do	do	do	Ontario	Agricultural implements	1	30	12		
Do	do	do	do	Flouring and grist	9	166	269		
Do	do	do	do	Saw	4	58	47		
Sundry small tributaries.	do	do	Seneca	Flouring and grist	1	16	19		
Do	do	do	Wayne	do	1	12	26		
Do	do	do	do	Saw	1	11	26		
Canandaigua outlet and tributaries (not including those running into Canandaigua lake).	do	do	do	Flouring and grist	2	17	110		
Do	do	do	Ontario	Agricultural implements	6	71½	120	10	
Do	do	do	do	Blacksmithing	1		5		
Do	do	do	do	Carriages and wagons	1	16	13		
Do	do	do	do	Carriage and wagon materials.	6	57+	125		
Do	do	do	do	Fertilizers	2	26	52		
Do	do	do	do	Flouring and grist	16	177½	584	80	
Do	do	do	do	Iron castings and finishings.	1	6	20		
Do	do	do	do	Paper	2	40	232	162	
Do	do	do	do	Saw	11	101½	224		

Table of utilized power on the Oswego river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Sundry tributaries.	Canandaigua lake.	New York	Ontario	Flouring and grist	4	83	130		
Do	do	do	do	Saw	3	67	81	75	
Do	do	do	do	Wheelwrighting	1	14	15		
Do	do	do	Yates	Flouring and grist	1	22	30		
Owasco outlet	Seneca river	do	Cayuga	Agricultural implements	5	Total fall in outlet, 330 feet—not all utilized.	671	465	
Do	do	do	do	Carpentering	1		28		
Do	do	do	do	Carpets	1		206		
Do	do	do	do	Chewing- and smoking-tobacco and snuff.	1		9		
Do	do	do	do	City water-works operated.	1		500		
Do	do	do	do	Fertilizers	1		50		
Do	do	do	do	Files	1		26		
Do	do	do	do	Flouring and grist	6		295	35	
Do	do	do	do	Hardware	1		140		
Do	do	do	do	Iron castings and finishings.	1		12		Principal manufacturing at Auburn.
Do	do	do	do	Iron, forged	1		300	450	
Do	do	do	do	Machinery	2		112		
Do	do	do	do	Models and patterns	1		26		
Do	do	do	do	Sashes, doors, and blinds	2		53	18	
Do	do	do	do	Saw	1		25		
Do	do	do	do	Starch	1		35	10	
Do	do	do	do	Tin, copper, and sheet-iron.	1		10		
Do	do	do	do	Washing-machines and clothes-wringers.	1		20		
Do	do	do	do	Woolen	4		480+	280	
Sundry tributaries.	Owasco lake and outlet.	do	do	Cooperage	1	70	54		
Do	do	do	do	Flouring and grist	13	236	544		
Do	do	do	do	Machinery	1	8	6	25	
Do	do	do	do	Pickles, preserves, and sauces.	1	16	10		
Do	do	do	do	Saw	14	357	530	35	
Do	do	do	do	Tannery	1	10	16	8	
Do	do	do	do	Wheelwrighting	1	23	10		
Do	do	do	do	Wood, turned and carved	1	6	14	15	
Do	do	do	do	Woolen	1	14	10		
Do	do	do	Tompkins	Flouring and grist	3	51	75	27	
Skaneateles outlet.	Seneca river	do	Onondaga	Cement	1	9	24		
Do	do	do	do	Fertilizers	1	8	39		
Do	do	do	do	Flouring and grist	6	60	540	45	
Do	do	do	do	Furniture	6	66	138		
Do	do	do	do	Iron castings and finishings.	1	9	15		
Do	do	do	do	Lumber, planed	3	25½	81	20	The total of fall utilized on the outlet can not accurately be determined from the figures here given, as some of the falls may be duplicated, the census enumerators' returns not distinguishing where several mills are located about a single dam, as is sometimes the case. Entire fall in outlet, about 485 feet.
Do	do	do	do	Machinery	3	20	57	20	
Do	do	do	do	Malt	1	18	30		
Do	do	do	do	Paper	6	80	515		
Do	do	do	do	Saw	1	8	22		
Do	do	do	do	Wheelbarrows	2	13	45	20	
Do	do	do	do	Woolen	2	34	60		
Tributaries	Skaneateles lake	do	Cortland	Animal oil	1	12	85		
Do	do	do	do	Flouring and grist	2	58	68		
Nine-Mile creek	Onondaga lake	do	Onondaga	do	6	122	315		
Do	do	do	do	Gunpowder	1		18		
Do	do	do	do	Lime	1	10	40		
Do	do	do	do	Machinery	1	19	40		
Do	do	do	do	Paper	2	32	228		
Do	do	do	do	Pearl-barley	1	14	15		
Do	do	do	do	Saw	5	101	112		
Do	do	do	do	Tannery	1	10	12		
Do	do	do	do	Wood, turned and carved	1	6	16		
Do	do	do	do	Woolen	3	46½	165		
Tributaries	Nine-Mile creek and Otisco lake.	do	do	Flouring and grist	4	117	65	10	
Do	do	do	do	Saw	5	126	124	10	
Onondaga creek and tributaries.	Onondaga lake	do	do	Flouring and grist	7	147	310	85	
Do	do	do	do	Saw	6	73+	135		

Table of utilized power on the Oswego river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Onondaga creek and tributaries.	Onondaga lake	New York	Onondaga	Wheelwrighting	1	13	4	....	
Other tributaries	...do	...do	...do	Fertilizers	1	26	32	....	
Sundry tributaries.	Seneca river	...do	...do	Flouring and grist	1	10	18	....	
Do	...do	...do	...do	Saw	1	14	20	....	
Do	...do	...do	...do	Tannery	1	8½	16	....	
Do	...do	...do	...do	Wheelbarrows	1	12	15	40	
Do	...do	...do	Cayuga	Cutlery and edge-tools	1	13	10	....	
Do	...do	...do	...do	Flouring and grist	4	57	80	....	
Do	...do	...do	...do	Saw	5	71	57	....	
Do	Oswego river	...do	Oswego	Flouring and grist	1	9	10	....	
Do	...do	...do	...do	Saw	3	30	61	....	
Do	...do	...do	...do	Tannery	1	11	12	....	

III.—THE GENESEE RIVER.

This river has its source in Potter county, northern Pennsylvania, 8 or 10 miles south of the New York boundary. Entering Allegany county of the latter state, it runs northwesterly 32 miles, by general course, but in the town of Caneadea turns, and pursues a northeasterly direction thence to the mouth, a distance measured in a straight line of about 63 miles. It empties into lake Ontario 7 miles north of Rochester. Besides passing across Allegany county, the river forms part of the boundary between the counties of Wyoming and Livingston, and then strikes successively across the latter and Monroe to the lake. By map measurement, the entire length following the bends is about 135 miles, and the drainage area 2,496 square miles. In the northern counties the surface is rolling, with long, easy slopes, except along the streams, which usually lie in deep ravines hemmed in by steep banks. There is a gradual rise, on the whole, away from the lakes, and in the upper half of the basin the country becomes rough and is broken by ridges the summits of which attain elevations of from 2,000 to 2,500 feet above tide. Splendid pine forests once covered this whole section, but have now mostly been cut away. The soil is of good quality and well suited to the raising of grain. In the extreme upper basin the slopes are too steep for convenient cultivation, but stock-raising, wool-growing, and dairying are everywhere successfully carried on, and are probably the leading industries. The prevailing rocks are sandstones, limestones, and shales. These supply abundance of fine building-stone, and by their disintegration form a fertile soil. Drift deposits are well distributed over this region, though they are not very extensive toward its southern limits.

Table showing the fall in the Genesee river.

Locality.	Distance above mouth, map measurement.	Elevation of water-surface above mean sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevation.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Belvidere crossing of the New York, Lake Erie, and Western railroad.	105.3	1,333				Levels of New York, Lake Erie, and Western railroad. (*a*)
			253	39.4	6.4	
Portage crossing of the New York, Lake Erie, and Western railroad.	65.9	1,080				Do.
			475	16.1	(*b*)	
Slack-water above Mount Morris dam	49.8	605				New York state canal profiles give elevation as 602.64 feet + mean low tide at Albany, = 604.71 feet + mean tide at New York.
			67	21.4	3.1	
Avon crossing of the New York, Lake Erie, and Western railroad, Rochester division.	28.4	538				Levels of New York, Lake Erie, and Western railroad.
			28	18.8	1.5	
Slack-water above feeder-dam at Rochester	9.6	510				New York state canal profiles give elevation in connecting level of Erie canal as 507.975 feet + mean low tide at Albany, = 510.045 feet + mean tide at New York.
			263	9.6	(*c*)	
Mean surface of lake Ontario	0.0	247				As stated at the office of the Chief of Engineers, U. S. army, the mean surface from January 1, 1860, to December 31, 1875, is 246.61 feet above mean tide at New York.

a For elevations on this railroad, thanks are due to Mr. O. Chanute, chief engineer.
b Descent occurs largely in abrupt falls and rapids at Portage and vicinity.
c Concentrated in abrupt falls at Rochester.

From the New York, Lake Erie, and Western Railroad crossing at Belvidere, near the center of Allegany county, down to the crossing by the same company's line at Portage, a distance of 39.4 miles, the fall in the water-surface is 253 feet, or an average of 6.4 feet per mile. At Portage the river plunges down in three magnificent falls. It

runs at the bottom of a deep gorge, which continues nearly to Mount Morris, and from under the Portage bridge to the crest of the old state dam at Mount Morris, 16.1 miles, the fall is 475 feet. Thence down to Rochester the river flows through a broad, open, and fertile valley, estimated to average nearly 2 miles in width, and is bordered by meadows subject to occasional overflow. In the vicinity of Mount Morris they are said to have been submerged three times in twenty years. The descent is moderate, and in the 40.2 miles from the crest of the Mount Morris dam to the crest of the state dam at Rochester the total fall is only 95 feet, or an average of 2.4 feet per mile. At Rochester the Genesee leaps down successively over three heavy falls, and within the city descends about 260 feet. Of the 1,086 feet of fall, therefore, occurring between Belvidere and the mouth, from 500 to 600 feet is found concentrated in abrupt pitches at Portage and Rochester, the power at the former point entirely undeveloped, while that at Rochester, though not fully utilized, sustains a very extensive amount of manufacturing.

With the steep slopes which characterize the upper basin, the stream naturally receives promptly the drainage from rainfalls, and in the upper course, at least, rises and falls quickly after heavy storms. In 1865, during a freshet, drift became lodged against the Erie Canal aqueduct at Rochester to such an extent as seriously to obstruct the flow of the stream, which overflowed into the canal and flooded the whole western part of the city. During the summer and autumn the volume of the river sinks quite low, and is also liable to be much reduced during an exceptionally cold period in winter. General I. F. Quinby, of the Rochester university, who for ten or fifeen years had charge of one or more of the hydraulic races at the city, states the average minimum discharge, as indicated by weir measurements, at 400 cubic feet per second, equivalent to about 0.16 cubic foot per second per square mile of drainage area. But, judging from the statements of prominent manufacturers, it appears that the net discharge, which the general use of weirs renders it possible to approximate to, has at times probably fallen considerably below 300 cubic feet per second, or below 0.12 cubic foot per second per square mile.

Above all the private dams at Rochester the state has a dam for the purpose of diverting water, through a feeder 2¼ miles long, to the Erie canal. It is so constructed that, except when put to its designed use, it may be left so as to form but a slight obstruction to the flow of the stream. Previously to the summer of 1878 it was but little used, except to assist in filling the canal in spring; but since that time it has regularly been employed to keep up the supply in the "long" level between Rochester and Lockport. It has thus occasioned quite a heavy draught on the river, to the extent, as claimed by some manufacturers, of reducing the low flow nearly one-half, and there is no reason for supposing that the demand will be much, if at all, lessened in the future.

In a report by Thomas Evershed, division engineer, in November, 1878,(*a*) it was stated that the capacity of the Rochester feeder was 1,400 cubic feet per minute (23 per second), and that much more would be afforded by properly maintaining the dam so as to force a supply through the feeder. Since the abandonment of the Genesee Valley canal, at the close of the season of 1878, about 1,200 cubic feet per minute (*b*) (20 per second) has been brought from Allen's creek, a tributary of the Genesee, some 10 or 11 miles through the old channel of the canal, to the Erie canal at Rochester. It is fair, therefore, to assume that during the period of canal navigation, at least 40 cubic feet per second, and very likely much more than that, is diverted from the river to the Erie canal.

In the basin of Black creek, one of the upper tributaries of the Genesee from the west, the state has two reservoirs, formerly used for supplying a part of the Genesee Valley canal, but, since that has been given up, retained for the benefit of the Erie canal, which their waters reach through a part of the Genesee Valley canal, the natural channels of Black creek and the main river, and the Rochester feeder. Of these, the Oil Creek reservoir has a water-surface of 605 acres, a mean depth of 20 feet, and a storage capacity of 527,214,000 cubic feet; the Rockville reservoir has a water-surface of 72 acres and a storage capacity of 18,223,000 cubic feet.(*c*)

The series of remarkable lakes farther eastward, tributary to the Oswego river, is continued westward into the Genesee basin, though they are there of smaller size, and includes Honeoye, Canadice, Hemlock, and Conesus lakes. No special data are at hand to show what facilities these possess for storage, or whether they are controlled by dams. Their outlets are described as good mill-streams, and probably owe their value largely to these natural reservoirs. Their areas, as given below, were obtained by planimeter measurement on French's map of the state:

Principal lakes and reservoirs in the basin of the Genesee river.

Name.	Location.	Area of water-surface.	Drainage area at head of outlet.	Name of outlet.
		Sq. miles.	*Sq. miles.*	
Honeoye lake	Southwestern part of Ontario county	2.8	39	Honeoye outlet.
Canadice lake	Town of Canadice, southwestern part of Ontario county	1.8	15	Canadice outlet.
Hemlock lake	Border between Ontario and Livingston counties	4.1	42	Hemlock outlet.
Conesus lake	Central part of Livingston county	4.8	67	Conesus outlet.
Silver lake	Mainly in town of Castile, Wyoming county	2.0	20	Silver Lake outlet.
Cuba or Oil Creek reservoir	Western border of Allegany county	0.95		Genesee Valley canal and Black creek.
Rockville reservoir	Town of Belfast, Allegany county	0.11		Do.

a See *Annual Report of the Superintendent of Public Works* for the year ending September 30, 1878.
b See *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879, p. 96.
c See *Annual Report of the State Engineer and Surveyor* for the year ending September 30, 1879, p. 99.

FIG. 7.—Middle falls of the Genesee river at Portage.

At Mount Morris there are several mills and shops, and at intervals elsewhere along the stream are small mills; but, notwithstanding the large aggregate fall, the power of the river, outside of Rochester, has been in general but slightly developed. The Genesee does not freeze very thick between Portage and Mount Morris, on account of the rapid current, and but little hinderance from ice is experienced at the latter point. At Rochester floating ice occasionally troubles at some of the head-gates, but neither that nor anchor-ice causes much difficulty to the mills.

Drainage areas of the Genesee river and principal tributaries.

Stream and locality.	Drainage area.	Stream and locality.	Drainage area.
	Sq. miles.		*Sq. miles.*
Genesee river at Phillipsville	358	Black creek (town of Belfast) at mouth	90
Genesee river at Portage	996	Canaseraga creek at mouth	347
Genesee river at Mount Morris	1,094	Conesus outlet at mouth	82
Genesee river at Geneseo	1,507	Honeoye outlet at Honeoye Falls	201
Genesee river at Rochester state dam	2,468	Honeoye outlet at mouth	272
Genesee river at Rochester, center of city	2,474	Oatka creek at mouth	215
Genesee river at mouth	2,496	Black creek (town of Chili) at mouth	184

Water-powers.—Examinations of this river did not extend above Portage, from which point to the head the census enumerators' returns show the only use of power to be by saw- and grist-mills. Though the valley widens out above the Portage falls and incloses extensive meadows, and is said to continue tolerably open for some distance above, it is described as being in general through Allegany county deep, and bordered by steep hill-sides. The principal villages along the stream in that county are Wellsville, population 2,000, Angelica 700, and Belmont 800.

As we have seen, the average descent in the 39 or 40 miles from Belvidere to Portage is about 6.4 feet per mile. Then follows the wonderful series of falls which has before been alluded to. These falls are distant about 65 miles by river from the mouth, and begin immediately below the crossing of the New York, Lake Erie, and Western railroad. The only settlement very near at hand is the little village of Portageville; 5 miles to the eastward is Nunda, with 1,000 inhabitants, and 3 or 4 miles to the northward Castile, with nearly the same population as Nunda. The Genesee Valley canal formerly descended the west bank, crossed over above the Portage falls, and making a detour to the eastward recrossed at Mount Morris, some 16 miles below. Since the abandonment of the canal its course has been followed part way by a railroad which, it is said, will be continued along the upper river.

At Portage the Genesee lies at the bottom of a deep and narrow ravine, the rocky sides of which rise, and in places very precipitously, to heights of from 250 to 400 feet from the water. The Erie railroad, as it crosses on the famous Portage viaduct, is over 230 feet above the crest of the Upper falls. There are three principal pitches, the Upper, Middle, and Lower, which occur in the horizontal strata of the Portage group (*a*) of rocks. The owner of the property gives the descent as 66 feet at the Upper falls, 110 feet at the Middle, and 90 feet at the Lower. These figures are probably for the more abrupt portions of the falls, and are somewhat less than the aggregate descents as given in the following description, which is taken from French's *Gazetteer of New York* (1860):

The Upper or Horseshoe falls are about three-fourths of a mile below Portageville. The name is derived from the curve in the face of the cliff over which the water flows. For a short distance above the edge of the precipice the water is broken by a succession of steps in the rock, forming a series of rapids. The height of the fall, including the rapids, is about 70 feet. The Middle falls are about one-half mile farther down the river. For two or three rods above the edge of the cliff the water is broken into rapids, and then in an unbroken sheet it pours down 110 feet into a chasm below, bounded by perpendicular ledges. A cave, called the "Devil's Oven", has been worn in the rocks under the west bank, near the bottom of the falls. In low water 100 persons can be seated within it; but when the river is high it is filled with water, and is only accessible by boats. The Lower falls consist of a series of rapids one-half mile in extent, with an aggregate fall of 150 feet. For about 2 miles below the Middle falls the river pursues a winding and rapid course between high perpendicular walls; then descends in a succession of steps almost as regular as a staircase, dives under a shelving rock, shoots out in a narrow pass not more than 15 feet wide, rushes down a nearly perpendicular descent of 20 feet, strikes against the base of high rocks standing almost directly in its course, whirls back, and, turning at nearly right angles, falls into a deep pool overhung with shelving rocks. An isolated mass of rocks, 15 feet in diameter and 100 feet high, known as "Sugar Loaf", rises from the river-bed at the bend of the stream and receives nearly the whole force of the rushing water. It is bordered on one side by the present bed of the stream, and on the other by a deep chasm which separates it from the east bank of the river. Within the memory of people now living, the river flowed over the precipice on the level of the rock which now forms its west bank, and "Sugar Loaf" was an island. These falls are accessible only from the west. The perpendicular bank on the west side of the river at one point is 380 feet high.

The aggregate of the falls proper may therefore be taken as 266 feet, and, including the rapids, as probably at least 330 feet, occurring in a distance of from 2 to 2½ miles. Opposite the Upper falls both banks are steep and rocky, but by tunneling say 200 feet on the west side, water could be brought out on to ground having a moderate slope and succeeded, down to the Middle falls, by a strip of level ground several hundred feet in width. On the east side of the river is the "canal" railroad, and the slope from the stream continues too steep to admit of convenient use of power. Years ago there was a saw-mill at the Middle falls. The power there could easily be utilized on the west bank, since the level piece of ground already mentioned comes close to the river, and there

a The Portage group comprises: Portage sandstone (upper); Gardeau flagstones; Coshaqua shales (lower).

is then a vertical drop to the pool below the falls. Mills could be located on the level ground, either close by or stretching up and away from the falls, and power taken by shafts. The Lower falls extend back in a fissure as a series of pitches. The right bank is there abrupt. The left or west bank recedes in a table of several acres 15 or 20 feet above the stream; there is then a second table, to which there is a steep rise of 75 or 80 feet from the first, and beyond is an ascent to high hills.

The Portage power is an important one, and could be used to good advantage in some kinds of manufacturing, though at present it is wholly undeveloped. It is evident, however, that the location for mills is not now convenient of access, being in a deep valley, far below the level of the railroad. Mr. William P. Letchworth, whose residence is close at hand, owns the privilege at the Upper, at the Middle, and part of that at the Lower falls. He states that he would be extremely unwilling to see the magnificent natural beauties of this locality marred by the introduction of manufacturing works, but would not desire to stand in the way of enterprises of sufficient importance to deserve being considered public improvements.

Estimate of power at Portage.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	THEORETICAL HORSE-POWER.					
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	66 feet, assumed for Upper falls.	110 feet, assumed for Middle falls.	90 feet, assumed for Lower falls.	266 feet, total of abrupt falls, as given by owner of the property.	330 feet, total of three falls and rapids, as given in French's *Gazetteer*.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*						
Low water, dry year							140	15.9	1,050	1,750	1,430	4,230	5,250
Low water, average year	8	10	8½	7	33½	996	190	21.6	1,430	2,380	1,940	5,750	7,130
Available 10 months, average year							280	31.8	2,100	3,500	2,860	8,460	10,490

From the Portage falls nearly to Mount Morris the river is described as running in constant heavy rapids, and most of the way through a gorge from 50 to 150 feet deep. At Mount Morris there is a leaky timber and stone dam, 335 feet long and 16 feet high. It was formerly owned by the state, the Genesee Valley canal crossing in the pool and being fed from it, but upon the abandonment of the canal the dam came into the hands of the race company. Water is brought to the mills through a head-race a mile long, 25 or 30 feet wide on the average, and not over 7 feet deep. It is said to be too small for the demands made upon it, and to be drawn quite low at times. The tail-race runs some 2 miles and empties into Canaseraga creek. The highest head obtained at Mount Morris is about 14 feet, but the average is stated as probably not over 12½ feet. Power is used by 3 grist- and flouring-mills, having together 12 sets of rollers and 10 runs of stone; and by a number of small establishments, comprising 2 machine-shops, 2 planing mills, a saw-mill, a cider-mill, and a plaster-mill. The power on the race is nominally divided into 40 equal shares, each share commanding a certain width of opening from the race. In some years there is abundance of water throughout for the wants of the mills, but in others there is a shortage for two or three months, though it is thought that this is due in considerable part to the leaky condition of the dam.

Estimate of power at Mount Morris.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*12½ feet fall.*	*14 feet fall.*	
Low water, dry year							150	17.0	210	240	
Low water, average year	8	10	8½	7	33½	1,094	200	22.7	280	320	a 370+
Available 10 months, average year							300	34.1	430	480	

a Returns incomplete.

From Mount Morris to Rochester the course of the stream lies through a flat open country and is quite winding. On either side are rich meadows devoted to grazing and to the raising of grain. The banks are usually low, but in places rise in bluffs. The bed is composed of clay and gravel with some quicksand. The surface of the water is now and then broken by ripples, but the fall is slight. At Geneseo there is a 4-run flouring- and grist-mill, using 5 feet of fall and 40 horse-power, and at York landing one of 3 runs, with 6 feet of fall and 30 horse-power.

Power at Rochester.—The first mill at this point is said to have been built in 1788 or 1789. By 1814 two more mills had been erected and small quantities of flour began to be exported to the Niagara frontier. The manufacture of flour steadily increased in importance, new flouring-mills were added, numerous other industries sprang up, and at the present time there are found here a variety and extent of manufacturing interests, based upon and in the main sustained by the water-power, which are equaled at few other cities. As nearly as could be ascertained, there

were, in the fall of 1882, flouring-mills in operation to the number of 17, with 134 sets of rollers, 30 runs of stone, and a probable aggregate production of at least 3,000 barrels of flour per day.(*a*) The manufacture of clothing is a great industry here, though not dependent upon water-power. Besides flour, as mentioned above, the productions of the various works receiving their motive power from the river include shoes, which are turned out in large numbers, cotton goods, paper; gauges, lanterns and lamps; stationary engines, car-wheels, screws, pins, and a great variety of general machinery, machinists' tools, and articles in wood.

In 1880 Rochester had a population of about 89,000, an increase of nearly 50 per cent. in the preceding ten years. The location of the city is admirable. Its foundation is solid limestone more or less overlaid by drift. It lies on both banks of the Genesee, and includes about 5 miles of the course of that river. The Erie canal passes directly through the city. The river itself is navigable nearly to the Lower falls, 5 miles from the lake, and at the mouth is the port of Charlotte, a place of about 1,000 inhabitants. The main line of the New York Central and Hudson River railroad passes through Rochester, and other important roads branch out in various directions.

From the pool above the state dam to the mean surface of the lake the descent in the river is 263 feet, nearly or quite all of which is within the city limits. There are three principal pitches, known respectively as the Upper, Middle, and Lower Genesee falls, which together embrace an aggregate abrupt fall of 205 feet.(*b*) French's *Gazetteer* says of them:

> The falls evidently all once formed a single cascade; but the different degrees of hardness of the several rocks over which the river flows have caused an unequal retrograde movement of the falls, until they have assumed their present position. The surface shales have worn away gradually to a uniform slope, over which the water flows in a series of rapids. At the Upper falls the stream falls a distance of 96 feet over the perpendicular edge of the Niagara limestone underlaid by shale. Below the Upper falls the river flows 1¾ mile, through a deep ravine bounded by nearly perpendicular sides, to the Middle falls, where it has a descent of 25 feet. One hundred rods below it descends 84 feet, over a ledge of Medina sandstone, to the level of lake Ontario.

The principal development of water-power, so far as concerns the number of mills, has been at the Upper Genesee falls, and at a privilege three-quarters of a mile above. At each of these localities there is a dam across the river, and on each bank is a hydraulic race conveying water for use in the mills and shops. They are in the heart of the city, where the ground is closely built upon, and, except perhaps at the Upton privilege, there is but little opportunity for erecting more works. The water-power interests appear to exist upon a very satisfactory basis. For the principal races commissioners are appointed by court, who attend to the proper adjustment of the weirs over which water is drawn into the mills. The entire privilege upon a race is divided into shares, and each mill has a width of weir-opening corresponding to the number of these owned. In abundant water the weirs are lowered so as to permit an unrestricted flow to the wheels, but in low stages of river they are raised to position, and adjusted as often as necessary, according to the volume at disposal, and in such manner that each mill shall secure its due proportion.

So far as could be learned, at all the water-privileges in Rochester, except possibly the Upton—where room and small amounts of power are rented or leased—practically all the rights to strictly permanent water are owned by the manufacturers. In many cases the available fall is not entirely developed, and in some the whole power of the stream, even with the head in use, is not utilized; the latter is true at the Lower falls, and the former both there and at the Upper falls. But, generally speaking, with the present development it is not more than nine or ten months in the year that all the mills and factories on the various races can be run at full capacity. For nearly that length of time, however, there is undoubtedly an important surplus power.

The uppermost dam in the city is that owned by the state and employed to divert water through the feeder to the "long" level of the Erie canal. This dam was not visited, but the fall there is said to be slight—not more than or 4 feet.

A mile and three-quarters below the head of the feeder there is a dam of rubble masonry, which was built in 1856 at a cost of $2,100; it is about 400 feet long, 5½ feet high, 4 feet wide at the top, and has a batter of 3 inches to the foot. Below the dam the river descends over a succession of low ledges, and opposite the foot of the rapids thus formed are the mills. On the east side is "the Johnson & Seymour canal-race", which passes under the Erie Canal aqueduct and under the mills, having a length of about half a mile. The width is 60 feet at the head, decreasing toward the foot. The water-depth is stated to be about 4 feet at the upper end. There were originally 19 equal rights upon this race, but it was extended and 32 second rights were created. As long as the supply of water is abundant no especial restrictions are placed upon its use; but when it becomes sufficiently reduced the second rights are successively shut down, the most recent deeds or leases first, and when the flow in the race falls to 9,500 cubic feet per minute (500 cubic feet per minute for each of the 19 first rights), the second rights are cut off altogether and the water is equally divided among the first rights. At such times a man examines the head-gates and the weirs at the mills twice a day and makes the proper adjustments to secure to each mill its share of the water. The flume-gates range from 1 to 15 feet in width, according to the number of rights owned. These gates or weirs are raised from below. Over each is a horizontal shaft turned by a hand-wheel. At either end of this

a Although the number of mills has somewhat decreased in recent years, the capacity of those remaining is said to have more than correspondingly increased.

b The remaining descent is comprised in rapids and falls over the dams, which are low.

shaft is a beveled cog-wheel, gearing into another at right angles, fastened upon a screw-shaft which serves to raise or lower the weir. The depth of water entering at the head-gates into the race, and the depths on the various weirs at the mills, are read off on a rod resembling an ordinary leveling-rod. The amount of water flowing into the race having been obtained from tables, and the amount due each mill determined, a weir-book shows readily the proper corresponding depth to be allowed on any particular weir. The adjustment having been made, the weir is secured against tampering by a short chain passed through a pair of adjacent cog-wheels, mentioned above, and fastened by a padlock.

The head obtained on this race ranges in general from 16 to 18 feet, and the power may be considered as fully utilized. During nine months in the year there is surplus water above all demands, but more or less shortage for the rest of the time. It was stated that the lowest allowance made to first rights had been 200 cubic feet per minute, and that in an ordinary summer season it is 300 cubic feet. Power is used by 6 flouring-mills, having altogether 45 sets of rollers, 17 runs of stone, and producing over 900 barrels of flour per day; and by 2 large machine-shops and founderies, a large furniture factory, a brewery, a tannery, a picture-frame molding establishment, a morocco-skin factory, a dental- and barber-chair factory, a billiard-table factory, wholesale rectifying works, and various other shops of small size. The flouring-mills own 16 of the 19 first rights, the other concerns depending mainly upon second rights.

On the west side of the river is "the Rochester, Fitzhugh, & Carroll canal-race",(*a*) from a quarter to a third of a mile in length, and varying in width from 25 to 60 feet. With a full pond it is about 5 feet deep, and gives a head at the mills of about 17 feet. The power is nominally divided into 76 equal shares, of which 32 are owned in connection with a large building and rented to various manufacturers. There being 456 inches width of water-way at the head-gates a share is entitled to 6 inches width of weir-opening. The power is all in use, and the mills are more or less short of water three months in the year. The manufacturing concerns supplied are 3 flouring-mills, 2 printing-offices, and various wood-working shops.

Three-quarters of a mile below the dam last described are the Upper Genesee falls. The river is there 275 or 300 feet wide, and at approximately that distance above the falls is crossed by a low timber dam turning the water into a race on each bank. On the right hand, or east, the bank below the falls is high, and consists of an almost vertical rock wall, and the race runs only to the edge of the fall. Here are located three water-wheels—two 48-inch Leffel under 26 feet head, and one 35-inch Leffel under 65 feet head. A 6-inch wrought-iron shaft extends 400 feet, up the bank from the wheel-pit, parallel to the river, and then a double line continues 400 feet farther. From these main shafts power is transferred throughout extensive buildings to a large number of manufacturing concerns, usually such, probably, as to require but small or moderate amounts of power in their operations. The transfer of power was formerly effected here, even in amounts of 200 or 300 horse-power, by cables, but these have been abandoned. Sheaves ranging in diameter from 10 feet downward were in use, but trouble was experienced from two principal causes—owing to the weight of the large cables the packing in the sheaves wore away rapidly, and the difficulty was much increased by the freezing of spray to the cables in winter, forming a coating of ice; and secondly, it was found that when power was suddenly taken off at any of the works the cable was apt to jump, strike against the flanges of the sheaves, and break the strands.

The whole of the privilege on the east side, with the buildings, formerly owned by the Rochester Hydraulic Company, is now the property of Mr. C. E. Upton. Room and power are rented or leased for short periods, the usual rental for power being $25 per annum per effective horse-power. There is room for more buildings, and these, it was stated by the agent in charge of the privilege, Mr. Upton proposes to erect as demand shall arise, and rent with power. Though the fall is not fully developed, there is said always to be sufficient power, with wheels as at present, to run at full capacity all the works that are in operation. In the fall of 1882 the Rochester Electric Light Company was the largest single user of power, having 175 horse-power and running 175 lights. Power was also rented to a considerable number of shoe-manufacturers, at least 9 or 10; to H. J. Howe & Co., scale-manufacturers; Horton's Edge Tool Manufacturing Company; Tigler's auger-works; the Spencer Fire Escape Company; 3 machine-shops; 2 sash- and blind-factories, and other shops of less note.

The rock at the Upper falls is in part soft and crumbly. It is evident that the falls themselves are gradually receding, and under an old mill at their east end it has been found necessary to build a supporting wall 65 feet high and ranging from 12 to 20 feet in thickness. On the west side the land adjoining the river is level and well suited to building, and the race, known as "Brown's race", is carried some distance below the falls, the wheel-pits being sunk in the rock. The shafts are generally lined with iron tubes, though sometimes with wood, and tail-water is discharged to the river through connecting tunnels. At the time this privilege was visited a shaft and tunnel had recently been completed for Farley, Ferguson, & Wilson's flouring-mill. The shaft is lined with iron tubing and is 40 feet deep; from it a tunnel runs 120 feet to the face of the cliffs. The rock had to be blasted out, and required the labor of 5 or 6 men for six months. No accurate information was obtained as to the fall from the crest of the dam to low-water surface at the foot of all the mills, but it is probably as much as 100 feet. The full available fall is not in use, however, by more than a very few, if it is by any, of the mills, and the heads employed range in

a "In 1802, Nathaniel Rochester, William Fitzhugh, and Charles H. Carroll, from Maryland, purchased a tract of 300 acres at the Upper falls, and in 1812 they caused their land to be laid out for settlement."—French's *Gazetteer*, page 404.

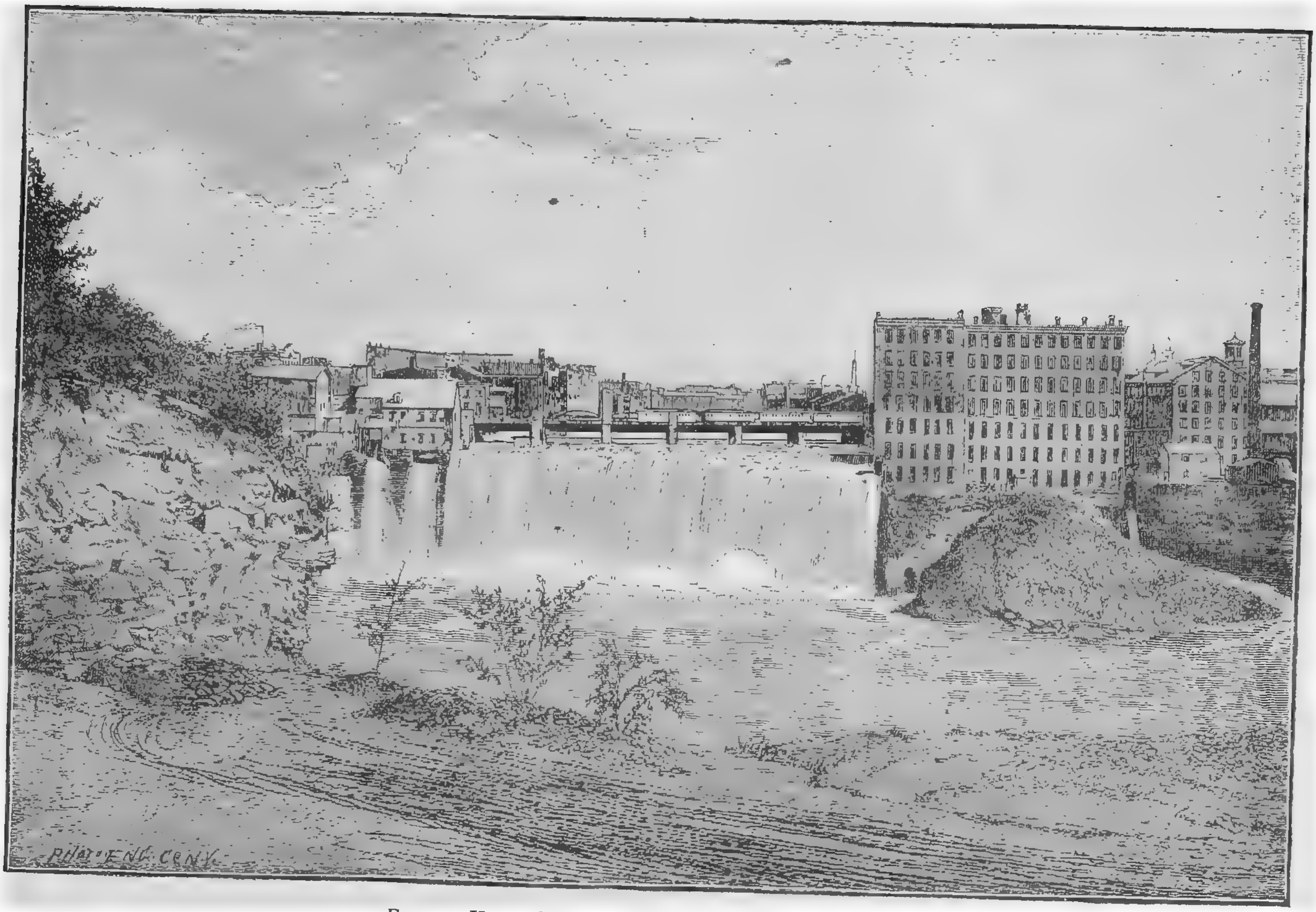

FIG. [illegible].—Upper falls in the Genesee river at Rochester.

general from 80 or 90 feet downward. The Steam Gauge & Lantern Company obtains a fall of 80 feet from the hydraulic race and 60 feet from one of the city sewers. It has 380 horse-power of wheels, and during abundant water relies upon the race alone, but when the supply from that source falls low it adds the sewer water. As the demands for the various manufactories and mills increase, the wheel-pits are sunk lower and the full development of the power is more nearly approached.

There is at the head-gates 49 feet width of water-way, and the whole power on the race is divided into 79 equal rights, each including about 7½ inches width of weir-opening. During a plentiful supply of water the weirs are not used, and the race may be drawn upon freely, but in low stages of river they are put in operation and properly adjusted by commissioners. In order that there may be the same depth of water falling over all the weirs into the mill-flumes, their absolute elevation gradually decreases toward the foot of the race, while their level, relatively to the water-surface in the race when all the mills are drawing, is intended to be uniform. For two or three months in the year there is a short supply of water, and more or less bargaining of it between the different mill owners.

Statistics of manufacturing on "Brown's race".

Firm or company.	Kind of mill or manufacture.	Remarks.
Rochester Cotton Mill	Prints	231 looms; 10,000 spindles; 48 feet fall.
Steam Gauge & Lantern Company	Gauges, lanterns, etc	Employs 265 men, and has 380 horse-power of wheels.
J. B. Stevens & Son	Packing-boxes	From 25 to 40 hands. This and a furniture factory receive power from the lantern factory.
Rochester Car Wheel Works	Car-wheels	From 35 to 40 hands. Capacity of works, 120 wheels per day, and in the fall of 1882 were turning out half that number.
A. J. Johnson & Co	Shoes	Employ about 400 hands, and in busy times turn out about 1,500 pairs of shoes per day.
Rochester Machine Screw Company	Machine-screws	50 hands.
R. Whalen & Co	Tobacco factory	25 hands.
William Gleason	Machinists' tools	80 hands; about 74 feet fall.
Kelly Lamp Company	Head-lights and lanterns	About 100 hands.
Junius Judson & Son	Steam-governors	From 140 to 150 hands.
Judson Pin Works	Pins	75 hands.
Judson Foundery		
Mach & Co	Edge-tools	200 hands.
F. P. Michel	Machinists' tools	About 30 hands.
Woodbury, Booth, & Pryor	Boilers and stationary steam-engines	From 70 to 120 hands; 50 feet fall.
J. G. Davis & Son	Flouring	60 feet fall; 10 sets of rollers; 200 barrels per day.
J. A. Hinds	do	60 feet fall; 12 sets of rollers; 2 runs of stone; from 225 to 250 barrels per day.
George F. Merz	Custom-mill	25 feet fall; 3 runs of stone; 7 sets of rollers.
Mosely & Motley	Two flouring-mills	46 single sets of rollers; combined capacity of mills, 500 barrels per day; falls in use, 66 and 56 feet.
Stone & Campbell	Flouring	5 runs of stone; 16-foot overshot wheel, below which is a turbine under 38 feet fall.
Boardman, Sherman, & Co	do	10 sets of rollers; 3 runs of stone; 200 barrels per day; 56 feet fall.
Farley, Ferguson, & Wilson	Custom and flouring	70 feet fall; 2 double sets of rollers.

NOTE.—In addition to the above there are many other small shops for the manufacture of all kinds of machine and wood work; the city water-works also receive power for pumping.

Between 1¼ and 1½ mile below the Upper falls are the Middle falls, with a natural pitch of 20 or 25 feet. A timber dam runs across in an irregular line, from 25 to 75 feet up stream from the crest. The entire privilege, including both sides of the river, is owned by the Rochester Paper Company, and all power not now employed is reserved for the company's use. On the east bank a small batting-mill utilizes not over 25 horse-power. On the west bank a short race leads to the paper-mill, where American and Leffel turbines with an aggregate of 1,200 horse-power are in use, running under a head of about 30 feet. The company makes news printing-paper, employing 100 hands, and produces 9 or 10 tons per day. The rag- and straw-pulp, and most of the wood-pulp, are manufactured in the works. For three or four months in about every year there is some scarcity of water, but it is thought that the supply would be sufficient were it not for the demands made at the feeder-dam for the Erie canal.

A quarter of a mile, more or less, below the Middle falls are the Lower falls, where the river suddenly plunges down nearly 90 feet. A low dam extending across at the top raises the available head for power to about 94 feet. Below the falls are rapids for a short distance, and then the river becomes smooth. It lies in a deep gorge, the rocky sides of which rise precipitously, on the west probably 30 and on the east at least 75 feet higher than the top of the falls. The rock strata in the banks are horizontal, and are composed of sandstone overlaid by blue limestone.

On the east side of the river all the power is owned by the Hydraulic Motor Company. Water is to be carried in a flume a short distance to a vertical tower which rests on a narrow shelf between the river and the side of the gorge. This tower contains two tubes designed for compressing air, which is to be conveyed in an iron pipe to the top of the neighboring bank. The intention is to supply this form of motive power to the street-cars of Rochester, but the enterprise advances very slowly.

On the west bank it is claimed that all the power is owned by the Hydraulic Motor Company, except 1,265 horse-power which is leased to the Brush Electric Light Company with privilege of sale. From this end of the

dam water passes through a timber bulkhead and a race cut in a projecting flat surface of rock for about 100 feet, to a wheel-house, and power is thence transferred by cable to the top of the adjoining bluff. A 165 horse-power wheel was in use in November, 1882, under a head of 34 feet, the power being partly employed by the Brush company in generating electricity. A building at the top of the bank was being occupied temporarily, but a new structure for the main works was being erected close to the river. It was stated that the company designed to expend some $45,000 here, and would extend its system of lighting over the whole city. A grist-mill and a small carpenter- and planing-shop are also supplied from the Brush company's building, the latter by a shaft and the former by a long cable.

The banks are so steep and rocky as to forbid long open races at this privilege, and therefore either the power must be distributed from one or two points near the falls, or water must be conveyed through tunnels, which would be practicable, though expensive. It was stated that new manufacturing enterprises could probably obtain power on the west bank, and there is some 10 acres of level ground adjacent which is finely suited to building. For most of the year there must evidently be a very great surplus power here; but without knowing definitely how much is likely to be required for the wants of the Brush and Hydraulic Motor companies it is of course impossible to estimate the amount of strictly permanent power remaining available for general manufacturing.

The New York Central and Hudson River railroad crosses the Genesee river immediately above the Upper falls, and between their crest and the dam which diverts water into the Brown and Upton races. According to the railroad levels the bed of the river beneath the bridge is 477 feet above ocean-level. The mean surface of lake Ontario being 247 feet above the same plane of reference, the fall from the top of the Upper falls to the lake is 230 feet. If we assume of this, 96 feet for the Upper falls below the bridge, 30 feet as the total descent at the Middle falls, and 94 feet at the Lower falls, then 220 feet is thus accounted for, leaving not over 10 feet to be made up by rapids and the gradual slope of the stream.

Estimate of power at Rochester.

Stage of river.	Rainfall on basin.					Drainage area.	Net flow per second, average for the 24 hours. (a)	Theoretical horse-power.							Total effective horse-power of wheels in use.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	17 feet fall, assumed for Upper privilege.	100 feet fall, assumed for privilege at Upper falls.	30 feet fall, assumed at Middle falls.	94 feet fall, assumed at Lower falls.	241 feet fall, total of four privileges.	263 feet fall, assumed as total within city limits.	
	In.	*In.*	*In.*	*In.*	*In.*	*Sq. miles.*	*Cu. feet.*								
Low water, dry year							300	34.1	580	3,410	1,020	3,210	8,220	8,970	
Low water, average year							350	39.8	680	3,980	1,190	3,740	9,590	10,470	
Available 10 months, average year							600	68.2	1,160	6,820	2,050	6,410	16,440	17,940	
Available 9 months, average year	8	9½	9	7	33½	2,474	830	94.3	1,600	9,430	2,830	8,860	22,720	24,800	6,442+
Available 8 months, average year							1,100	125.0	2,120	12,500	3,750	11,750	30,120	32,880	
Available 7 months, average year							1,570	178.4	3,030	17,840	5,350	16,770	42,990	46,920	
Available 6 months, average year							2,060	234.0	3,980	23,400	7,020	22,000	56,400	61,540	

a Although certain statements made to the author indicate that the discharge at Rochester has been known to fall even lower than the lowest figures here assumed, yet such occurrences appear to have been so exceptional and of so short duration that they are here neglected.

Table of utilized power on the Genesee river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Genesee river	Lake Ontario	Pennsylvania	Potter	Saw	5	74	97	....
Do	do	do	do	Woolen	2	19	30	....
Do	do	New York	Allegany	Flouring and grist	8	58	226	....
Do	do	do	do	Machinery	2	24	124	....
Do	do	do	do	Saw	6	59	188	....
Do	do	do	Wyoming	Flouring and grist	1	7½	35	....
Do	do	do	do	Saw	1	12	75	....
Do	do	do	Livingston	Flouring and grist	3	Mt. Morris—fall, 14 feet.	145+	....
Do	do	do	do	Machinery	2		200	....
Do	do	do	do	Planing	1		....	....
Do	do	do	do	Plaster	1		....	....
Do	do	do	do	Saw	1		25	....
Do	do	do	do	Flouring and grist	a 1	5	40	....
Do	do	do	do	do	b 1	6	30	....

a Geneseo. b York.

FIG. 9.—Lower falls in the Genesee river at Rochester.

Table of utilized power on the Genesee river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Genesee river	Lake Ontario	New York	Monroe	Agricultural implements	2	Rochester—total fall at four privileges, 241 feet, of which perhaps 170 or 180 feet is actually utilized.	41	....
Do	do	do	do	Architectural and ornamental iron-work	1		35	....
Do	do	do	do	Axles	1		30	....
Do	do	do	do	Billiard tables	1		....	....
Do	do	do	do	Blacking	1		20	....
Do	do	do	do	Boots and shoes	9		191	....
Do	do	do	do	Boot and shoe cut stock	1		12	....
Do	do	do	do	Boilers and steam-engines	1		....	....
Do	do	do	do	Brewery	1		....	....
Do	do	do	do	Carpentering	2		78	....
Do	do	do	do	Car-wheels	1		....	....
Do	do	do	do	Chairs	3		95	30
Do	do	do	do	Cigar-boxes	3		31	....
Do	do	do	do	Cotton	2		138	....
Do	do	do	do	Cutlery and edge-tools	8		339	....
Do	do	do	do	Electric lighting	2		349	....
Do	do	do	do	Fire-escapes	1		....	....
Do	do	do	do	Fire-proof safes, doors, and vaults	1		2	....
Do	do	do	do	Files	2		29	....
Do	do	do	do	Flouring and grist	17		1,520	....
Do	do	do	do	Furniture	6		158	75
Do	do	do	do	Hardware	2		75	....
Do	do	do	do	Iron castings	1		10	....
Do	do	do	do	Iron forgings	1		30	....
Do	do	do	do	Ivory and bone work	1		15	....
Do	do	do	do	Lasts	2		60	....
Do	do	do	do	Looking-glass and picture frames	4		83	....
Do	do	do	do	Machinery	19		581	....
Do	do	do	do	Models and patterns	1		45	....
Do	do	do	do	Morocco-skin factory	1		....	....
Do	do	do	do	Needles and pins	1		180	....
Do	do	do	do	Paper	1		1,200	....
Do	do	do	do	Printing and publishing	2		60	11
Do	do	do	do	Professional and scientific instruments	1		5	....
Do	do	do	do	Rectifying works	1		....	....
Do	do	do	do	Sashes, doors, and blinds	5		87	....
Do	do	do	do	Scales and balances	2		50	....
Do	do	do	do	Steam-gauges and lanterns	1		380	....
Do	do	do	do	Silverware	1		1	....
Do	do	do	do	Soap and candles	1		35	....
Do	do	do	do	Steam-fitting and heating apparatus	1		60	....
Do	do	do	do	Tobacco factory	1		....	....
Do	do	do	do	Tannery	1		....	....
Do	do	do	do	Tools	1		120	....
Do	do	do	do	Trunks and valises	1		50	....
Do	do	do	do	Watch and clock repairing	1		2	....
Do	do	do	do	Wooden packing-boxes	2		95	51
Do	do	do	do	Wood, turned and carved	8		146	....
Do	do	do	do	Women's clothing	2		13	....
Canaseraga creek and tributaries	Genesee river	do	Allegany	Flouring and grist	1	31	40	....
Do	do	do	Steuben	do	3	70	104	....
Do	do	do	do	Saw	1	14	14	....
Do	do	do	Livingston	Flouring and grist	11	180	523	....
Do	do	do	do	Pumps	2	31	24	....
Do	do	do	do	Sashes, doors, and blinds	1	12	30	....
Do	do	do	do	Saw	6	120	160	....
Do	do	do	do	Wooden ware	1	16	20	....
Conesus outlet and tributaries	do	do	do	Flouring and grist	7	176	332	42
Do	do	do	do	Saw	1	10	60	....
Honeoye creek and tributaries	do	do	do	Flouring and grist	7	125	224	33
Do	do	do	do	Saw	4	78	115	4
Do	do	do	Monroe	Agricultural implements, etc	1	6	15	....
Do	do	do	do	Fertilizers	1	23	65	....
Do	do	do	do	Flouring and grist	5	84	308	....
Do	do	do	do	Sashes, doors, and blinds	1	15	25	....
Do	do	do	do	Saw	2	42	98	....

Table of utilized power on the Genesee river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Honeoye creek and tributaries	Genesee river	New York	Monroe	Woolen	1	11	20	
Do	do	do	Ontario	Carriage and wagon materials	1	14	14	
Do	do	do	do	Flouring and grist	6	102	211	
Do	do	do	do	Machinery	1	12½	12	
Do	do	do	do	Paper	1	15	90	40
Do	do	do	do	Saw	5	58½	173	
Oatka creek and tributaries	do	do	Wyoming	Cooperage	1	12	20	
Do	do	do	do	Flouring and grist	6	78	154	
Do	do	do	do	Machinery	1	8	12	
Do	do	do	do	Saw	2	25	46	
Do	do	do	do	Wood, turned and carved	1	14	12	
Do	do	do	Monroe	Fertilizers	2	32	137	
Do	do	do	do	Flouring and grist	5	80	233	20
Do	do	do	do	Woolen	1	6	18	
Do	do	do	Genesee	Agricultural implements	1	5	20	
Do	do	do	do	Fertilizers	1	4	50	
Do	do	do	do	Flouring and grist	4	49	183	
Do	do	do	do	Linseed oil	1	7	2	
Do	do	do	do	Paper	1	28	50	
Do	do	do	do	Sashes, doors, and blinds	1	7	6	
Do	do	do	do	Saw	2	22	45	
Black creek and tributaries	do	do	Monroe	Flouring and grist	2	8+	90	30
Do	do	do	do	Saw	1	8	20	
Do	do	do	Genesee	Flouring and grist	7	141	275	65
Do	do	do	do	Saw	4	70	61	
Do	do	do	do	Woolen	1	20	15	
Sundry other tributaries	do	Pennsylvania	Potter	Flouring and grist	1	20	15	
Do	do	New York	Allegany	do	17	311	476	45
Do	do	do	do	Paper	1	20	55	75
Do	do	do	do	Saw	12	165	411	
Do	do	do	Wyoming	Agricultural implements	3	38	123	
Do	do	do	do	Cooperage	1	9	12	
Do	do	do	do	Flax, dressed	2	29	33	
Do	do	do	do	Flouring and grist	11	186	349	
Do	do	do	do	Lumber, planed	1		10	
Do	do	do	do	Sashes, doors, and blinds	1	18	15	
Do	do	do	do	Saw	11	121	342	
Do	do	do	do	Wooden ware	1	10	53	
Do	do	do	do	Woolen	2	29	47	
Do	do	do	Livingston	Flouring and grist	2	34	80	
Do	do	do	do	Saw	1	20	20	
Do	do	do	Monroe	Flouring and grist	2	15	70	

Table of utilized power on sundry streams flowing into lake Ontario.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Sandy creek and tributaries	Lake Ontario	New York	Jefferson	Blacksmithing	2	24	26	
Do	do	do	do	Carpentering	1	12	20	
Do	do	do	do	Cooperage	1	12	12	
Do	do	do	do	Flouring and grist	12	159	462	15
Do	do	do	do	Furniture	2	25	20	
Do	do	do	do	Lumber, planed	1	12	20	10
Do	do	do	do	Paper	1	18	50	
Do	do	do	do	Sashes, doors, and blinds	1	9	15	
Do	do	do	do	Saw	21	244	443	
Do	do	do	do	Tannery	1	6	21	12
Do	do	do	do	Wooden handles	1	14	10	

Table of utilized power on sundry streams flowing into lake Ontario—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Sandy creek and tributaries	Lake Ontario	New York	Jefferson	Woolen	1	18	12	
Do	do	do	Lewis	Furniture	1	14	6	
Do	do	do	do	Saw	3	30	61	25
Salmon river and tributaries	do	do	Oswego	Cooperage	1	5	10	
Do	do	do	do	Flouring and grist	6	57	288	
Do	do	do	do	Furniture	1	5	10	
Do	do	do	do	Machinery	1	10	15	
Do	do	do	do	Paper	2	22½	120	
Do	do	do	do	Sashes, doors, and blinds	3	20	65	
Do	do	do	do	Saw	19	176½	399	
Do	do	do	do	Tanneries	3	23	39	
Do	do	do	do	Wheelwrighting	1	5	20	
Do	do	do	do	Wooden packing-boxes	1	12	20	
Do	do	do	do	Woolen	1	15	20	
Do	do	do	Lewis	Saw	5	52	183	
Irondequoit creek and tributaries	do	do	Monroe	Paper	1	18	111	
Do	do	do	do	Flouring and grist	6	75½	237	
Do	do	do	Ontario	do	2	16+	80	
Oak Orchard creek and tributaries	do	do	Orleans	Agricultural implements	2	18	30	
Do	do	do	do	Carpentering	1	7	10	
Do	do	do	do	Flouring and grist	8	139	464	
Do	do	do	do	Machinery	2	32	245	
Do	do	do	do	Paper	1	21	88	84
Do	do	do	do	Saw	7	110½	350	126
Do	do	do	Genesee	Flouring and grist	1	21	46	
Do	do	do	Niagara	do	1	15	80	
Do	do	do	do	Saw	2	22	50	
Eighteen-Mile creek and tributaries	do	do	do	Agricultural implements	1	7	10	
Do	do	do	do	Flouring and grist	4	62	300	
Do	do	do	do	Saw	3	37	98	70
Other small streams	do	do	Jefferson	Agricultural implements	1	12	22	
Do	do	do	do	Butter and cheese	1	3	1	
Do	do	do	do	Flouring and grist	9	130	343	53
Do	do	do	do	Sashes, doors, and blinds	1	22	6	
Do	do	do	do	Saw	7	74½	253	55
Do	do	do	Oswego	Agricultural implements	1	9	10	
Do	do	do	do	Carpentering	1	12	8	
Do	do	do	do	Cooperage	1	4	10	
Do	do	do	do	Flouring and grist	13	166	710	
Do	do	do	do	Iron castings and finishings	1	8	28	18
Do	do	do	do	Lumber, planed	1	10	8	
Do	do	do	do	Machinery	1	9	10	
Do	do	do	do	Sashes, doors, and blinds	3	28	50	
Do	do	do	do	Saw	42	438½	937	10
Do	do	do	do	Tannery	1	10	18	15
Do	do	do	do	Wheelwrighting	1	9	4	
Do	do	do	do	Woolen	2	12+	34	
Do	do	do	Cayuga	Flouring and grist	4	52	135	
Do	do	do	do	Saw	8	82	235	30
Do	do	do	Wayne	Flax, dressed	1	9	12	
Do	do	do	do	Flouring and grist	12	185	490	180
Do	do	do	do	Pumps	1	8	10	
Do	do	do	do	Saw	11	134½	200	15
Do	do	do	Monroe	Flouring and grist	10	174	520	20
Do	do	do	do	Saw	4	50	60	
Do	do	do	Orleans	Flouring and grist	8	181	460	
Do	do	do	do	Pickles, preserves, and sauces	1	11	36	
Do	do	do	do	Saw	4	64	153	
Do	do	do	do	Vinegar	2	23	44	
Do	do	do	Niagara	Flouring and grist	1	10½	50	
Do	do	do	do	Paper	1	13	50	
Do	do	do	do	Saw	2	37	80	

Summary of utilized power on streams tributary to

	Stream.	Flouring- and grist-mills. Number of mills.	Flouring- and grist-mills. Water-power utilized.	Flouring- and grist-mills. Auxiliary steam-power.	Saw-mills. Number of mills.	Saw-mills. Water-power utilized.	Saw-mills. Auxiliary steam-power.	Paper-mills. (a) Number of mills.	Paper-mills. (a) Water-power utilized.	Paper-mills. (a) Auxiliary steam-power.
			H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
1	Black river and tributaries	35	2, 235	65	81	2, 737	....	11	4, 707	....
2	Oswego river and tributaries	258	12, 590	814	227	5, 906	295	26	2, 047	207
3	Genesee river and tributaries	126	5, 667	235	65	1, 950	4	4	1, 395	115
4	Sundry other streams	97	4, 665	268	138	3, 502	331	6	419	84
	Total	516	25, 157	1, 382	511	14, 095	630	47	8, 568	406

a Including two or three pulp-mills.

NOTE.—The class of "metal-working establishments" includes works for the manufacture of agricultural implements, architectural and ornamental iron-work, iron forgings; sewing-machines and materials, pumps, vacuum-brakes, and general machinery; lamps and reflectors, needles and pins, professional and scientific

The class of "wood-working establishments" includes planing- and shingle-mills; carpentering, cooperage, wheelwrighting, and wood-turning and carving looking-glass and picture frames, models and patterns, organs, packing-boxes, piano materials, sashes, doors, and blinds; washing-machines and clothes-wringers,

The class of "sundry other establishments" includes 1 carpet factory, 4 cotton factories, 5 hosiery-mills, 1 silk-mill, 2 electric-lighting works, 1 dry-dock, 3 grain-elevators, printing and publishing works, tanneries, 1 stone-quarry; and concerns engaged in the manufacture of animal oil, blacking, boots and shoes and whetstones, ivory and bone work, lime, malt, morocco; pickles, preserves and sauces; soap and candles, starch, sporting goods, table-mats, trunks and valises, and

lake Ontario (not including the Niagara river).

WOOLEN-MILLS. (*b*)			METAL-WORKING ESTABLISHMENTS.			WOOD-WORKING ESTABLISHMENTS.			SUNDRY OTHER ESTABLISHMENTS.			TOTAL.			
Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	
	H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*	
4	42	....	14	879	30	41	1, 299	57	26	1, 130	233	212	13, 029	385	1
23	2, 492	572	64	2, 691	1, 155	80	1, 941	313	70	3, 821	812	748	31, 488	4, 168	2
7	130	....	59	2, 088	....	50	1, 125	156	38	1, 543	13	349	13, 898	523	3
4	66	....	13	406	18	24	330	10	10	171	27	292	9, 559	738	4
38	2, 730	572	150	6, 064	1, 203	195	4, 695	536	144	6, 665	1, 085	1, 601	67, 974	5, 814	

b Including a worsted-mill, a hosiery-mill, and a knit-underwear mill.

boilers and steam-engines, car-wheels, cutlery and edge-tools, files, and general hardware; fire-proof safes, doors, and vaults; iron castings and finishings, and instruments, scales and balances, silver-ware, steam-fitting and heating apparatus, surgical appliances, tin-, copper-, and sheet-iron ware.

shops; and works for the manufacture of axles, billiard-tables, carriages and wagons and materials, chairs, cigar-boxes, coffins and burial-cases, furniture, lasts, wheelbarrows, window-blinds and shades, wooden handles, and wooden ware.

pumping-works for water-supply, breweries, distilleries; millwrighting, flax-dressing, wool-carding, watch- and clock-repairing, and file shops; rectifying works, cut-stock; bread, crackers, etc.; butter and cheese, cement, fertilizers, plaster, chewing- and smoking-tobacco and snuff, flux, fire-escapes, gunpowder, hones and women's clothing.

WATER-POWER

OF THE

NEW YORK STATE CANALS.

477—59

WATER-POWER OF THE NEW YORK STATE CANALS.

Although the Champlain canal was completed as far back as 1823, the Erie in 1825, and the more important of the other New York canals within the succeeding eight years, there were, at the period of their construction, numerous mills scattered through the state which were run by water-power, some of them occupying privileges on streams that were more or less interfered with for feeding the canals and that had their flow diverted to the injury of the mills. Where such diversions were made the owners of the privileges were permitted, under certain conditions, to draw off surplus water from the canals or at the feeder-dams, as the case might be. If the powers at the dams were not thus taken up, then the state sold or leased the rights of the surplus waters to the highest bidders. In this way it has come about that at many of the feeder-dams, and at some points on the lines of the canals, powers are in use that are dependent on the state improvements. Equitable as the granting of these rights may have been originally, the rentals received now appear very small in comparison with the value of the privileges; there is a natural tendency to disregard the rights of the state and to draw down the levels, and, so far as concerns the working of the canals, the withdrawals for hydraulic power can not be regarded as other than prejudicial, though perhaps not greatly so. As late as 1880, at least, the relative rights of the state and of individuals regarding these privileges were an unsettled and disputed question, and the policy observed by the former was not to lease or in any other way dispose of more water.

According to a report made in March, 1871, by the auditor of the New York canal department, there were in force at that time 18 water-leases, yielding to the state a total annual rental of about $3,400. Of this amount, $200 was derived from the surplus water at the head of the locks at Lockport; $210 from the surplus at the Glens Falls feeder-dam; $550 from the surplus at the Troy and Lansingburg dam on the Hudson river, and between $1,500 and $1,600 from surplus waters leased at Black Rock, at the western terminus of the Erie canal.

POWER AT LOCKPORT.

In the 31 miles from the Buffalo terminus to Lockport the Erie canal is without lift-locks, and the only change in level is that due to a very small slope in the water-surface, and amounting to but 0.8 of a foot in the whole distance. At Lockport there is a sudden descent in a flight of five combined double locks, with a total fall of between 57 and 58 feet, and a second long level succeeds for 62 miles to Rochester, in which the additional fall is only 3.2 feet.(a) At Black Rock, 4 miles to the north of Buffalo, an abundant supply of water is received from the Niagara river. This is indeed the main dependence as far east as the Montezuma level, 140 or 150 miles from the western terminus. The prevalence of a strong east wind, however, is liable to interfere at times with the delivery of water at so great a distance, and the same difficulty, to a much more serious and lasting extent, is caused by the heavy growth of eel-grass in the canal in summer, and at such times additional feeders along its course have to be more or less relied upon. The quantity of water necessary to meet the demands of this long stretch of canal must evidently be large, and is stated by Mr. Olmstead, civil engineer, of Lockport, to be from 30,000 to 36,000 cubic feet per minute, or from 500 to 600 cubic feet per second.

The flight of locks at Lockport lies in a deep and narrow ravine which opens out considerably below, and which was once the valley of a small "wet-weather" creek. The rock strata forming the sides of the ravine are composed of limestone for from 12 to 18 feet down from the surface, below which depth there is for a long distance a hard blue shale. The combined demands of the hydraulic races and of lockage do not at all times equal the volume flowing in the canal, and in order to pass the surplus the state has a waste-way running down beside the locks and emptying into the lower level. Some distance beyond, in the lower part of the city, a considerable discharge of surplus water passes from the canal over a weir into Eighteen-Mile creek, and on its way through that stream to lake Ontario furnishes power to a number of mills.

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a The various figures for the changes in level of the water-surface of the canal are drawn from a profile of the western division accompanying the *Annual Report of the Superintendent of Public Works* for the year ending September 30, 1881.

From the level above the locks two hydraulic races open out, one on each side. That on the south follows along the steep side of the ravine into which it is cut, being supported in part on the outer side by wall and embankment. This race has a water-depth of 6 feet, and, where the topography and material passed through admit, side-slopes of 1 to 1 and a width at bottom of 12 feet. It is perhaps half a mile in length, and tolerably uniform in size, except as it contracts to pass through an arched opening under a road-way. On the line of the race are supplied six flouring-mills, having in the aggregate 13 runs of stone, 65 sets of rollers, and a capacity of 1,200 or 1,300 barrels of flour per day. Still another large flouring-mill draws independently from the Erie canal. Power is also furnished to the works of the Pound Manufacturing Company, employing 50 men and turning out stationary and marine engines, derricks, dredges, etc. The Penfield Block Company has a large establishment in which it makes tackle and hoisting-blocks, sheaves, trucks, and barrows, giving employment to over 50 hands. Trevor & Co. have 40 hands at work in the manufacture of shingle, heading, stave, and wood-pulp machinery. Small powers are also used for a number of printing-presses and goods-elevators, a grain-elevator, two bakeries, two machine-shops, and in a variety of other shops of moderate size, including in their productions faucets, agricultural implements, shirts, patterns, oil, and sashes and blinds.

On the north side a main tunnel, 8 by 12 feet in size, extends from 350 to 400 feet to the works of the Holly Manufacturing Company, manufacturer of water-works machinery, and employing 300 hands. A short intersecting or branch tunnel supplies the Richmond Manufacturing Company, employing 45 hands on flouring-mill machinery. Besides the more direct use of power from turbines, wire cables are quite commonly availed of at Lockport for transmitting power. This mode of transmission is here limited to rather small powers, probably not exceeding 20 or 30 horse-power in any one case. The longest interval overcome by cable is in the neighborhood of 1,500 feet. From the Pound Manufacturing Company's works, which are located on the south slope of the ravine, seven cables run up to the top of the slope and transfer power to a number of printing and small manufacturing shops. The cables are three-eighths of an inch in diameter, and the largest sheave used is 6 feet in diameter. Cables have been run here for periods ranging from two to seven years without wearing out. They are thoroughly coated every week with tar, and the sheaves are packed with tarred rope.

Lockport is a city of 13,500 inhabitants, lying northeasterly from Buffalo, and distant from that city 26 miles by the New York Central and Hudson River railroad. The water-power here described is mainly controlled by the Lockport Hydraulic Company, which bought out the rights of the old lessees. Flour has always been a leading production at this point, but with the growth of the city other branches of manufacturing have also come into prominence. The Hydraulic company owns unoccupied land along its races, but looks for profit chiefly in the disposal of power, and is willing to sell land to manufacturers at very low rates. A perpetual lease is given of the power, and the lessee has the privilege of making the title absolute at any time by paying a principal sum which at 7 per cent. interest would yield the amount of the annual rental. In case of a deficiency in the supply of water, the right of any owner or lessee to its use is subject to all rights conveyed by prior grants or leases. Water is leased in so-called "runs", which are assumed equivalent to 12 effective horse-power each, the number of cubic feet being adjusted to the fall to be employed so as to produce that equivalence. The manner of this adjustment and the condition under which water shall be drawn are thus expressed in the leases:

And the parties of the first and second part, respectively, for themselves and their successors, executors, administrators, and assigns, grant, covenant, and agree, each to and with the other party, —— executors, administrators, successors, heirs, or assigns, as follows: The term "twelve horse-power", as used herein, is defined, and shall be construed, to mean a water-power equivalent to the power given by the discharge and use of —— cubic feet of water in each second when the fall or difference in elevation between the surface water levels of the said —— and the lower or Genesee level of the Erie canal, from and into which the water is to be drawn and discharged, shall be —— feet; and as the fall may sometimes vary from ice, change of levels, or other causes, the quantity of water drawn under this grant shall be increased or diminished as the fall with which it can be used as aforesaid is diminished or increased; and to avoid uncertainty the following table is agreed upon as stating correctly the number of cubic feet of water per second necessary to give one "twelve horse-power" as aforesaid, with each different and respective fall therein given:

Table giving the number of cubic feet of water per second which is equivalent to "twelve horse-power", on different falls, allowing 25 per cent. for waste and friction.(a)

	Cubic feet per second.
24 feet fall	6.700
25 feet fall	6.432
26 feet fall	6.184
27 feet fall	5.955
28 feet fall	5.544
29 feet fall	5.360
etc., etc.	

The water is to be drawn through a water-tight trunk or pipe, and such trunk or pipe and the water-wheels, apertures, and other apparatus for drawing the water shall be constructed of sufficient capacity and proper form to enable the grantee to use more or less water, according to the variations of fall as aforesaid.

a According to the table, the allowance for waste and friction appears to be about 35 rather than 25 per cent.

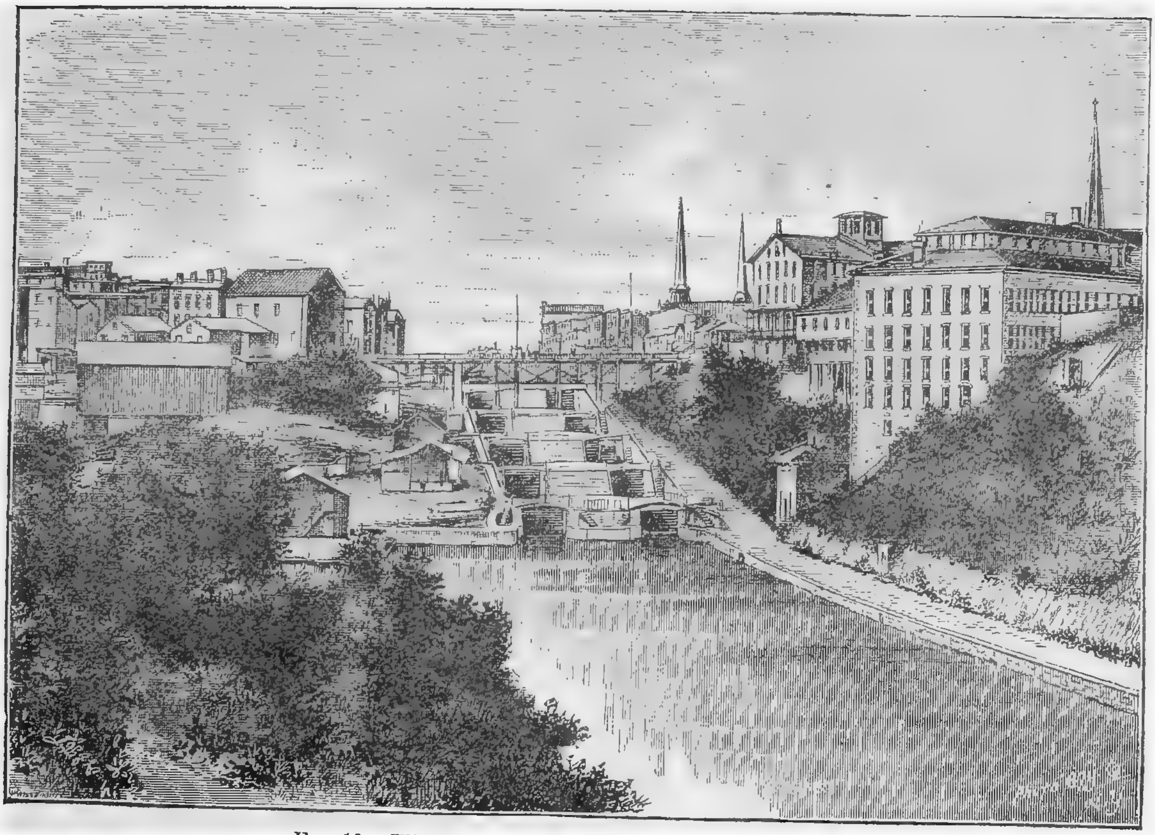

FIG. 10.—Flight of locks in the Erie canal at Lockport.

Assuming the figures previously given—from 500 to 600 cubic feet per second—as the full supply passing through the Erie canal, and allowing 100 cubic feet per second to the possible demands of lockage, there remains say from 400 to 500 cubic feet per second available for power. With a fall of 57 feet the resulting power will be as shown in the following table:

Estimate of power at Lockport.

Assumed volume of water.	Assumed fall.	Corresponding theoretical horse-power.	Corresponding effective horse-power, at 65 per cent. efficiency.	Corresponding number of "twelve horse-power" runs.	Number of runs owned independently of Hydraulic company.	Number of runs rented by company.	Runs remaining not disposed of.	Effective horse-power (at 65 per cent.) remaining not disposed of.
Cu. feet per sec.	*Feet.*							
100	1	11.36	7.38	0.61	....	....	....	....
100	57	647.52	420.89	35+	....	....	....	....
400	57	2,590.00	1,684.00	140+	24	a 45	71+	856.00
500	57	3,238.00	2,104.00	175+	24	a 45	106+	1,276.00

a December 1, 1882.

NOTE.—By census enumerators' returns the total rated capacity of wheels in place in 1880 was upward of 1,400 effective horse-power; but these wheels are doubtless rated at a considerably higher efficiency than 65 per cent.

It appears, therefore, that with a full stage of water, supposing an average efficiency of 65 per cent. to be attained in its use, the entire privilege is equivalent to from 1,680 to 2,100 effective horse-power, or, at 12 horse-power to the run, to from 140 to 175 runs. But 24 of these runs are owned by individuals who bought before the Hydraulic company, and who are consequently independent of it. On the 1st of December, 1882, 45 runs in addition had been rented by the company to manufacturers, leaving, according to this estimate, from 70 to something over 100 runs, or say from 850 to 1,250 or 1,300 effective horse-power still available.

The rental charged by the company ranges from $150 to $200 per annum per run, or from $12 50 to $16 67 per effective horse-power. The amount of water used by consumers is judged mainly by the wheel-ratings, with occasional measurements in tail-races. It is not probable that the actual surplus of water unemployed would supply the 850 to 1,250 horse-power which has been estimated above, although, of course, by a strict system of measurements it could be appropriated for that purpose. As it is, many of the wheels in use are extremely wasteful, and doubtless draw much more water than they are entitled to. It is said that a decree of court has directed the use of fixed weirs, over which water should be drawn into the various flumes, but they are not generally, if at all, used. In one instance, it was found that, restricting a certain miller by means of a weir, in the specified manner, to the amount of water which was properly his due, he was not able even to start his wheels. It is thought that a system of fixed weirs would not work satisfactorily here, on this account: At Black Rock, where the Erie canal is fed from the Niagara river, the millers employing water-power are in the habit of partially closing the gates into the canal during winter, it being claimed that their own power is thereby slightly benefited; the level at Lockport is thus lowered, even to the extent of 2 or 3 feet, and little or no water would pass over fixed weirs properly adjusted to a full stage.

Although the flow in the canal is quite uniformly maintained in summer, it is during the rest of the year at times much reduced and even stopped. The trouble due to the action of the millers at Black Rock sometimes continues all winter. Again, for from two to four weeks every spring the state has the water entirely drawn out from the canal to admit of inspection and repairs. The Lockport factories are then dependent upon steam-power, while the flouring-mills shut down altogether. For the greater part of the year, however, the hydraulic power at this point is steady and reliable, and is capable of supporting much more manufacturing than at present. Very slight hinderance is experienced from anchor-ice. At times in winter, when the south race becomes drawn down, ice freezes to the bottom and impedes the flow of water; but as soon as the level rises again the current carries along this ice and it is shot out of the race at certain points. At the lower end of the race the experiment has been tried of covering it with planking, which has proved quite successful in guarding against the formation of thick ice. The race on the north side of the ravine, being inclosed in a tunnel, is protected and free from all ice.

Table of utilized power on the New York state canals.(a)

[From returns by census enumerators.]

Canal.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
				Feet.	*H. P.*	*H. P.*
Erie	Niagara	Agricultural implements	1			
Do	...do	Blocks, sheaves, etc	1			
Do	...do	Cotton-batting	1			
Do	...do	Fruits and vegetables, canned and prepared	1			
Do	...do	Flouring and grist	7			
Do	...do	Goods-elevators	(?)			
Do	...do	Grain-elevator	1	Lockport—total fall available, about 57 feet.	1,421	350
Do	...do	Iron castings and finishings	1			
Do	...do	Leather, tanned and curried	1			
Do	...do	Machinery	6			
Do	...do	Printing-presses operated	(?)			
Do	...do	Shirts	1			
Do	...do	Woolen	1			
Do	Monroe	Furniture	1	14	58	12
Do	...do	Saw	1	14	58	....
Do	Oneida	...do	1	8	30	....
Do	Onondaga	Flouring and grist	1	26	200	....
Black River	Oneida	Sashes, doors, and blinds	1	10	24	15
Do	...do	Saw	4	27+	95	....
Oswego	Onondaga	Salt	1	27	75	90
Champlain	Albany	Hardware	1	10½	80	60
Do	Saratoga	Brooms and brushes	1	11	28	....
Do	...do	Hosiery	1	20	90	....
Do	...do	Machinery	1	8	45	30
Do	...do	Saw	2	32	119	....
Do	Washington	...do	2	26	68	....

a Powers at feeder-dams are classed with the rivers on which the dams are located.

INDEX TO REPORT ON WATER-POWER OF REGION TRIBUTARY TO LAKE ONTARIO.

REPORT ON THE WATER-POWERS

OF THE

DRAINAGE BASINS OF LAKES HURON AND ERIE,

IN THE

UNITED STATES,

WITH REPORT ON THE

WATER-POWER OF THE NIAGARA RIVER,

BY

JAMES L. GREENLEAF, C. E.,

INSTRUCTOR IN ENGINEERING AT THE SCHOOL OF MINES, COLUMBIA COLLEGE, NEW YORK CITY,

AND

SPECIAL AGENT TENTH CENSUS.

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THE WATER-POWER OF NIAGARA RIVER AND FALLS.

LIST OF ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

NEW YORK, N. Y., *April* 1, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York, N. Y.

SIR: I beg to submit herewith my report on the water-powers of the drainage-basins of lakes Huron and Erie in the United States, and on the water-power of the Niagara river.

Most of the investigations on which this report is based were made in the winter and spring of 1880–'81, and it should be remembered that since that time considerable changes have taken place in the power utilized, especially so at Niagara falls, where important improvements were being made during my visit.

Very respectfully,

JAMES L. GREENLEAF,

Special Agent.

EASTERN DRAINAGE AREA OF THE LOWER PENINSULA OF MICHIGAN.

GENERAL DESCRIPTION OF THE REGION.

The area is bounded on the east by lake Huron, Saint Clair river, lake Saint Clair, Detroit river, and lake Erie. The distance from these navigable waters to the line of water-shed is not more than 70 or 80 miles. The land is quite level, rising toward the northern part. In the lower part the soil is a sandy or gravelly clay, well adapted to raising wheat, which is the staple. In the northern part there is much pine lumber cut. The rivers are short and not of large size; those in the upper part of the region are mainly devoted to rafting. There are no very important water-powers to be found.

No rivers north of the Saint Clair were visited. There are powers in use on the northern rivers, especially the Thunder Bay river, but they are used for saw-mills and local grist-mills, and have not the importance they will probably possess when the country is more settled.

The rivers have only in a few instances reached the rock; they have worn their beds in the drift, which here covers the rock in a deep layer. Hence the dams have mostly an earth foundation, which is, however, a compact gravelly clay, and the banks are usually high enough to restrain the ponds within small limits.

None of the rivers are navigable except for short distances, and are used, as far as shipping is concerned, only for harbors. The fact that many of the rivers on which it would now be almost impracticable to float even a flat-boat have been once declared navigable by the legislature or by Congress, indicates the change in flow that has taken place, owing to the clearing and draining of the land.

HURON RIVER.

General description.—The Huron river rises in the town of Clarkston, Oakland county, Michigan, and runs southwest into Livingston county, draining many lakes in Oakland county. The chief of these are White, Union, Upper Straits, Lower Straits, Pine, and Spring lakes, averaging ½ to 1 square mile in area. In the southeast part of Livingston county it takes the waters of four lakes, viz, First Base lake, Second Base lake, Strawberry lake, and Portage lake, varying from 1 to 2 square miles in area. Portage lake is the largest and also the lowest down the valley of all the lakes drained by the Huron. It is 3 or 4 miles long, and averages about ½ mile in width. It is fed by Portage river, which itself drains ten lakes of small size. From there the Huron flows northeast, then southeast again, and enters lake Erie just below the mouth of the Detroit river. The total drainage area is 950 square miles.

The country is flat or rolling, with a glacial drift of clay, sand, and gravel, well adapted to the raising of wheat, which is the staple, and gives work to many flouring-mills. The river was declared navigable by Congress. Once a flat-boat for freighting ran from Ypsilanti 30 miles to the mouth, but its use was discontinued on the advent of railroads. There was too little water for navigation, and the dams interfered. Boats run up to Rockwood, 4 or 5 miles upon the line of the Lake Shore and Michigan Southern railroad.

No lumbering is done, and the stream is devoted to manufacturing, for which it stands peculiar among the rivers of the region. It has a fall averaging 5 feet per mile, and this near its mouth. It is in line of several railroads, and, owing to its lakes, the storage capacity is large and its flow more regular than that of various other rivers of the country. There has been talk for some years of throwing a dam across the outlet of Portage lake and increasing the storage, but nothing has been done as yet. The banks of the river are usually from 9 to 12 feet high, and hence ponds do not spread. The bed and banks are usually hard clay, or a sort of conglomerate of clay, gravel, and stone. There is no rock bed except at Flat Rock, the first fall above the mouth.

The course is extremely winding. The Michigan Central railroad runs along the river 17 miles from Ypsilanti to Dexter, and in that distance crosses it sixteen times. The bulk of the manufacturing is done between Dexter and Ypsilanti, on the line of the Michigan Central railroad.

The Michigan Southern railroad crosses at Rockwood, the Chicago and Canada Southern railroad crosses at Flat Rock, and the Flint and Père Marquette railroad crosses at New Boston. There is a road projected between Detroit and Adrian, in Lenawee county, which will cross at Belleville and open up a short stretch of river.

Character of the river.—At Ypsilanti, the center of use of power, the average breadth is 100 feet, average depth 1½ foot, and the maximum depth about 5 feet. The ordinary low-water flow, calculated from the estimated horse-power given, is 220 cubic feet per second, or 0.23 cubic foot per second per square mile of drainage area. The available power under 10 feet head at ordinary low water is from 225 to 250 horse-power. There is no difficulty from floating ice. A mill using the full average power of the stream can run full capacity ten months of the year, and during September and August at half capacity. The river has no large tributaries below the lakes, and hence the power for a given fall is nearly the same in the upper as in the lower part.

DESCRIPTION OF THE DEVELOPED POWER.

Most of the mills are between Dexter and Ypsilanti, a distance of 17 miles. Above Dexter and below Portage lake are the Hudson and the Dover mills. Below Ypsilanti are mills at Rawsonville, Belleville, etc.

Three methods have been employed for building dams: 1. The pile dam, a common form. A typical specimen is one belonging to the Ypsilanti Paper Company. Piles were driven 6 feet between centers, both across and lengthwise of the stream, till they covered a strip 50 feet wide running across the channel. The ends were then cut, so that taken together their surface formed two planes meeting at the center line of the dam, like a roof. The space between the piles was filled in with stone and the top planked over. A plank apron was built on the lower side. 2. The crib-work dam—ordinary timber cribs, filled with stone and planked over. 3. The frame dam, used at the Dover mills. A triangular frame was built and planked over and stone thrown under; a plank apron built on the lower side, and gravel thrown in on the upper side. So far as ascertained, there have been no instances of the breaking away of dams.

Flat Rock.—At Flat Rock, 7 or 8 miles above the mouth of the river, is the first power. There is about 100 horse-power available.

New Boston and Belleville.—At New Boston and at Belleville are powers which are being developed. There are two flouring-mills at Belleville. Banks high and well adapted to ponding.

Rawsonville.—At Rawsonville is a flouring-mill with 7 feet head. There is 150 to 175 horse-power available.

Ypsilanti.—Ypsilanti is the chief manufacturing center on the river. There are three paper-mills, two flouring-mills, a woolen-mill, and a small custom saw-mill. The banks are from 9 to 12 feet high, and ponds do not spread. There are three dams with about one-half to three-fourths of a mile between them, and there is no fall wasted. The bed is hard clay. The Michigan Central railroad runs up the valley from this point, and freight facilities are good.

The lower pond has 7 feet available fall and 175 available horse-power. Pile dam, 190 feet long. Average breadth of pond, about 150 feet; length, half a mile. Power utilized by Ypsilanti Paper Company's mill.

The middle pond has 5 feet available head and 125 available horse-power. The only mill at the power is the Huron flouring-mill, using, on the average, 75 horse-power. Pile dam, 5 to 6 feet high and 100 feet long. Pond, from 150 to 200 feet broad and half a mile long.

The upper pond is owned by the City flouring-mill and the woolen-mill, and runs them, as also a small saw-mill fed from the race of the flouring-mill. The fall at the dam is 8 feet and the available power is 225 horse-power. Dam, from 120 to 130 feet long; area of pond, 35 acres, and depth 5 or 6 feet; it does not spread much. The woolen-mill uses 42 horse-power. The flouring-mill, situated on a race, has 1 foot additional fall, making it 9 feet; it uses 100 horse-power. The saw-mill uses, when running, about 10 horse-power.

Peninsula Paper Company's mills.—The mills of the Peninsula Paper Company are situated at a pond a short distance above Ypsilanti, and have 300 available horse-power.

Lowell.—The largest power on the river is at Lowell, and is used by the Ypsilanti Paper Company. The available head is 16 feet, and 400 horse-power is available. The pile dam has been described; its length is 166 feet. The area of the pond is 30 or 35 acres.

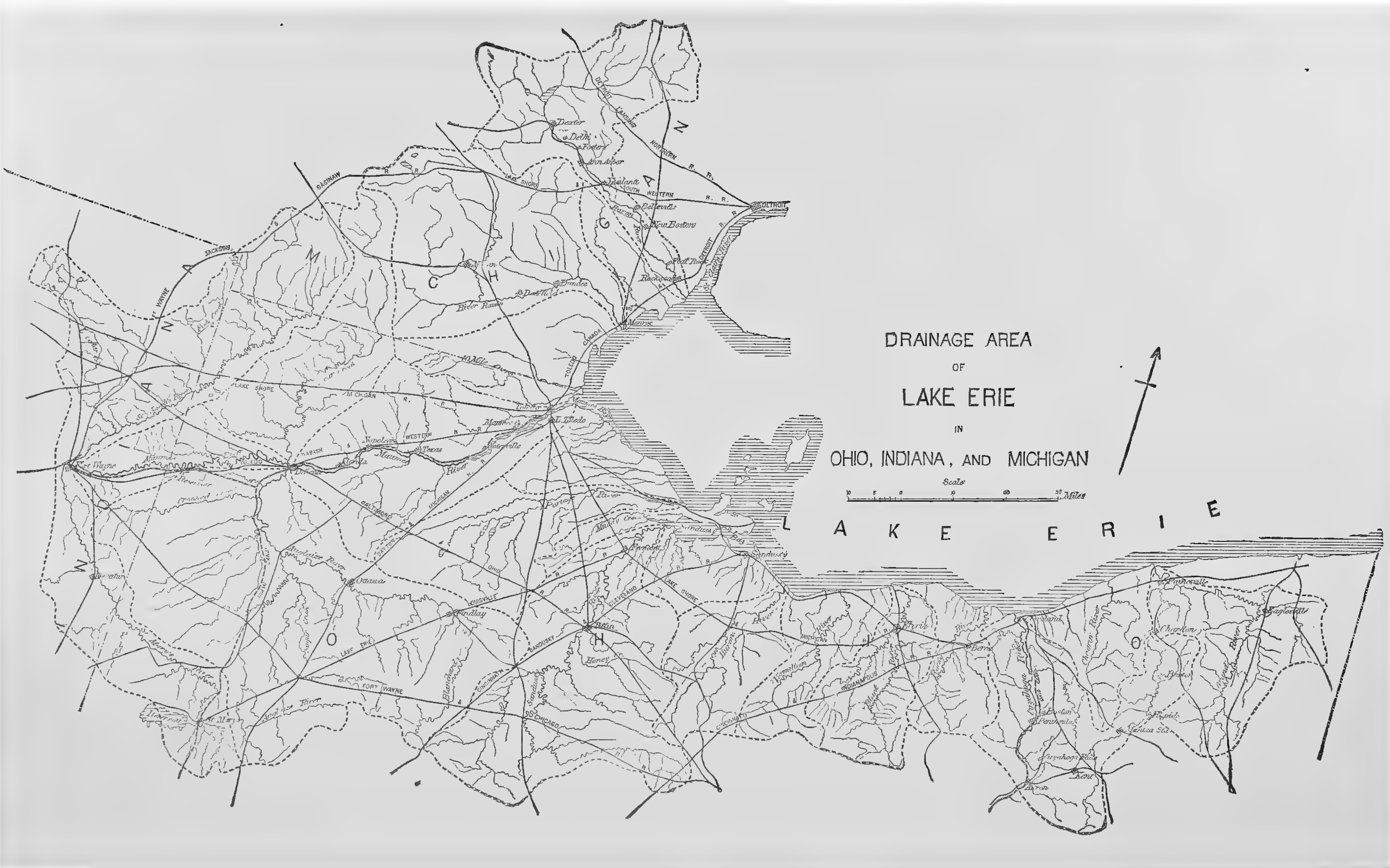
Ann Arbor.—At Ann Arbor, 7 or 8 miles above Ypsilanti, there is a level with a head of 10 feet and 250 horse-power available. The dam is a pile dam 200 feet long; it is utilized by the Ypsilanti Paper Company's mill. Above it is another level with the same head and power. There are a woolen-mill, flouring-mill, and saw-mill fed from this pond, using altogether 100 horse-power. The dam is 140 feet long.

Foster's Station.—At Foster's Station, 3 miles from Ann Arbor, there is a fall of 9 feet, all of which is utilized by a paper-mill taking 100 horse-power, and a woolen-mill with 58 horse-power. The power is considered to be 300 horse-power for six months of the year.

Delhi.—At Delhi there are 2 flouring-mills, a woolen-mill, and a saw-mill, all using from the same level. Seven feet head and 140 horse-power are available. Usually all can run at once. The dam is a crib-work 150 feet long.

The Scio flouring-mills are above Delhi, and have 8 feet fall, with 140 available horse-power. The dam is a crib-work 100 feet long.

Dexter.—Dexter has a flouring-mill, a woolen-mill, and a saw-mill, all run from the same level. The available head is 5 feet. The dam is a crib-work 75 feet long.


DRAINAGE AREA
OF
LAKE ERIE
IN
OHIO, INDIANA, AND MICHIGAN
Scale
Miles
LAKE ERIE
MICHIGAN
INDIANA
OHIO
Detroit
Toledo
Monroe
Sandusky
Fort Wayne
Findlay
Tiffin
Ann Arbor
Defiance
Kent
Akron
Painesville
Elyria
Norwalk
Berea
Ottawa
Napoleon
Ypsilanti
Dexter
Maumee River
River Raisin
Portage River
Huron River
Vermilion River
Black River
Cuyahoga River
Chagrin River
Grand River
Sandusky River
Blanchard River
St. Marys River
Auglaize River
DETROIT, LANSING & NORTHERN R. R.
LAKE SHORE
MICHIGAN
SOUTHERN
WABASH
LAKE ERIE
FORT WAYNE
CHICAGO
CINCINNATI
INDIANAPOLIS
CLEVELAND
BALTIMORE
OHIO
TOLEDO
CANADA
SAGINAW
JACKSON

Above Dexter.—Above Dexter are the Hudson mills, with 5 feet head and 75 horse-power—a crib-work dam 100 feet long—and the Dover Mills, with 7 feet head and 100 horse-power—a frame dam 100 feet long. The ponds above Ann Arbor average from 120 to 180 feet wide, and ½ mile to 2 miles long. There are no important powers above.

UNIMPROVED POWERS.

There are few undeveloped powers. Three miles below Ypsilanti is one of 300 horse-power, which has not been used, because the pond would spread over valuable farming land, and also because the location is not near the railroad. One mile below Ann Arbor is a power with 4 or 5 feet fall unimproved, giving from 100 to 125 horse-power. It is on the line of the railroad. The small power, compared with the cost of improvement and lack of demand for it, is the apparent reason why it is not improved. One and one-half mile above Ann Arbor is a fall of 10 feet unimproved. Nearly 300 horse-power is wasted. It was used formerly by a saw-mill, now burnt down. It is on the line of railroad, and awaits improvement.

RAISIN RIVER.

The North branch rises in Jackson county, and the South branch in the northwestern corner of Ohio. They unite east of the center of Lenawee county and flow into lake Erie. The drainage area is 1,162 square miles. Near the mouth it is 200 or 300 feet wide, and would be thought a large stream, but it is, in ordinary water, only from 6 to 12 inches deep, with a sluggish current. At Adrian it is a small stream, 25 or 30 feet wide, with a moderate current, about 1 foot deep. There are several small mills on the river, but no power of importance.

SOUTHERN DRAINAGE AREA OF LAKE ERIE.

GENERAL DESCRIPTION OF THE REGION.

The average altitude of the water-shed above lake Erie is 500 feet. It crosses Ohio from northeast to southwest. Entering in Ashtabula and Trumbull counties it runs through the north line of Wayne and Richland, through Hardin, Auglaize, and northern Darke county into Indiana.

Along the shore of lake Erie the water-shed hardly runs back more than 50 miles from the lake, but in western Ohio it extends nearly half way down the state line. This gives a longer surface of drainage in that section, and hence the Maumee is the largest stream of northern Ohio. The elevation, however, at its head, Fort Wayne, is only 170 feet above the lake level. The headwaters of the Cuyahoga, in eastern Ohio, are 500 feet above the lake. The soil is mostly the Erie clay (in the southern part of the shed more arenaceous), which was deposited by a body of water in a blanket over all irregularities of surface. This has been worn by the stream into undulating ground, but the surface is everywhere of only slight variation where not level. Owing to the narrowness of the region of drainage the streams are small, the chief being the Maumee, the Sandusky, and the Cuyahoga, and the power is not very considerable. The land is well adapted to the raising of corn and wheat, which are the staples, except in the northeastern part of Ohio, where there is a section devoted to cheese- and butter-making. The timber is largely oak, some beech and maple, and a few firs. One peculiarity concerning the water-power is, that a large part of it is situated on the canals, the Miami and Erie entering the lake at Toledo, and the Ohio canal entering at Cleveland. These canals are controlled by the state of Ohio, and the power is rented to the manufacturers. The universal opinion of the persons consulted was, that the rivers had become unsteady in flow since the country was cleared and drained; some rivers that once were steady and gave good power are now so flashy that the mills have been abandoned or are being run by steam.

MAUMEE RIVER.

The Maumee river is formed at Fort Wayne, Indiana, by the junction of the Saint Joseph and the Saint Mary's rivers, and flows northeast into lake Erie, at Toledo. The chief tributaries below the junction are the Auglaize and the Tiffin.

The drainage area in square miles above different points is as follows: At the junction, 2,055; above Tiffin river, 2,412; below Tiffin river, 3,135; below Auglaize river, 5,676; at the mouth, 6,723.

The country is flat, and the river has not worn its valley very deep. The soil is the Erie clay, which when not too heavy is well adapted to the raising of wheat and corn, the staple crops. Farming is the occupation of the people. There are many limestone quarries locally used for building, and some brick-yards. In places are many artesian wells. Oak timber covers a considerable portion of the land. Oak is rafted to some extent from the headwaters of the Auglaize.

The Miami and Erie canal runs up the valley to Defiance, and then turns south. It is carried in the river by slack-water navigation from Providence to Defiance, a distance of about 30 miles. The river is practically taken

up by the canal, and hence no power is used to any extent from it, but there is a large amount taken from the canal itself. South Toledo is the head of natural navigation 18 miles from the mouth. Here begin the rapids, which continue about 1 mile. There are also rapids at Waterville and Otsego. All these are of no value, because, except when the water is high, there is no regularity in the flow, owing to the canal taking it.

The river is 600 feet wide at South Toledo and from 1 to 6 or 7 feet deep. It is subject to high freshets—the Saint Joseph rose 23 feet above low water at Fort Wayne on March 28, 1868—and after hard winters there is too much floating ice.

While the river is spoiled for milling purposes by the canal, yet the manufacturers gain in having their power from the canal much more securely than they could get it direct from the river. There are only two powers used from the river direct. One at Perrysburg, opposite South Toledo, takes its water by a race 5 miles long from a small dam just below the canal dam at Providence, and gets what water flows over the canal dam. It is a very unsteady power, and steam is also used. The other is opposite Providence, and is fed by a race 1½ mile long from the canal pond. From Providence to Defiance the fall is all taken up by the slack-water for navigation. From Defiance to Fort Wayne there is some fall, but not utilized.

The bed of the river is rock, up to Defiance at least, with clay and gravel banks. At Fort Wayne the bed partakes more of a gravelly and clayey nature, for the river has not eroded to the rock at its upper part.

Twenty-four miles above Defiance are the Bull rapids, where there is a fall of 14 feet. There is a rock bed, and banks high enough to confine the pond. This is not utilized, but backwater during floods is a serious objection to using the power on the upper part of the river. The flow of the Maumee at Fort Wayne during ordinary low water was estimated by an engineer at 116.6 cubic feet per second, which is 0.57 cubic foot per second per square mile.

TRIBUTARIES OF THE MAUMEE RIVER.

SAINT JOSEPH RIVER.

The Saint Joseph river rises in Michigan and flows southwest into Indiana, uniting at Fort Wayne with the Saint Mary's to form the Maumee. The drainage area is 1,292 square miles.

These rivers change their course through an angle of about 150 degrees at Fort Wayne. This may be due to the fact that these rivers once emptied into the outlet of the lake which flowed down the Wabash valley, and have their directions changed by the subsidence of the lake level, and the wearing of their beds below the level of the headwaters of the Little river, which occupies the old channel. The river gives in ordinary low water 67 cubic feet per second; fifty years ago it was estimated to give 83 cubic feet per second.

There is considerable fall in the river—3 feet per mile near the mouth—and the census returns show a total of twenty-four grist- and saw-mills, using 925 horse-power. The highest head is 26 feet. By throwing dams across the Saint Mary's and Saint Joseph, and bringing the water to Fort Wayne in canals, a flow of 117 cubic feet per second can be obtained with 17½ feet available fall, giving 232 theoretical horse-power. The project is feasible.

SAINT MARY'S RIVER.

The Saint Mary's river has 763 square miles of drainage area. The ordinary low flow is estimated to be 33 cubic feet per second. There is power at the mouth which can be utilized at Fort Wayne, as just mentioned.

The ordinary low-water flow has been much increased by taking the overflow of the 15,000-acre canal reservoir in Mercer and Auglaize counties. There are only three mills on the Saint Mary's, and these use a total of 210 horse-power. The bed and banks are generally clay and gravel.

AUGLAIZE RIVER.

The Auglaize river enters from the south at Defiance. It divides into two large branches at Franconia—one from the east and the other from the south. The drainage area is 2,541 square miles. It is 300 feet wide and 1½ foot deep during low water near the mouth. The average grade for 5 miles above Defiance is 6 feet per mile. By building a dam 2 miles above Defiance and running the water along the bank in a canal there could be obtained in Defiance a fall of 30 feet. Mills could be stationed along the side of the canal on the river-bank. For about $10,000, it is said, a fine power could be obtained.

The grade to Delphos, 50 miles, averages nearly 6 feet per mile. Ten miles above Defiance is a fall which might be utilized. The bed and banks are generally clay and gravel. The river is subject to high freshets. There are only three mills on the river, using 82 horse-power, but a dam could be thrown across nearly every 3 miles without interfering. The chief difficulty is backwater during freshets.

TIFFIN RIVER.

The Tiffin river rises in Michigan, and after draining 723 square miles enters the Maumee 2 or 3 miles above the Auglaize river. There is a total of 16 grist- and saw-mills on the river, using 590 horse-power, but none are very important. A survey has shown it practicable to cut a canal from Brunersburg down into Sulphur Hollow, at Defiance, and obtain a large head there.

MIAMI AND ERIE CANAL.

Practically all the utilized water-power of the Maumee valley up to Defiance is on the canal. It was formerly called the Wabash and Erie. It is practically discontinued west from Defiance, but runs south from there to Cincinnati. At Providence a dam gives slack-water in the Maumee to Independence, and another dam there continues it to Defiance. The Providence dam was built in 1872.

The old dam leaked badly and was dangerous. The bed is rock. Ten feet below the old dam a crib of timber 10 feet wide filled with stone was placed across the stream. The space between was filled with gravel, and the whole was planked over. The dam is built on both sides of an island, and averages from 6 to 8 feet high.

UTILIZED POWERS OF THE CANAL.

The total power in use on the canal within the water-shed is about 2,000 horse-power. The millers complain that the feeding of the canal is not regular, and as they get only the surplus from what is needed for locking, they are sometimes short for water. The average surplus is about 45 cubic feet per second at Toledo.

Toledo.—At Toledo are the Pilloid flouring-mills, which use 12 feet fall and pay $800 per year, and the Amada mills, which have 24 feet fall and average 120 horse-power.

South Toledo.—At South Toledo are three paper-mills, two flour- and grist-mills, a woolen-mill, a cotton factory, and a foundery. Four of the powers are taken direct from the canal, and four from the tail-races or head-races of the others. The heads used are 31, 11, 16½, 16½, 16½, 24, 16½, and 16⅝ feet, respectively. The total power used is about 520 horse-power.

Waterville.—At Waterville are a grist- and a saw-mill, using 60 and 25 horse-power, under 17 and 16 feet head of water, respectively.

Providence.—At Providence is a flour- and grist-mill using 20 horse-power. The head is 9 feet, and 100 horse-power is available.

Texas.—There is a mill at Texas using 15 horse-power under 17 feet head. The available head is 21 feet.

Damascus.—At Damascus is an available power of 21 feet, of which a saw-mill uses 18 feet and 18 horse-power.

Napoleon.—At Napoleon are two flouring-mills, a woolen-mill, a planing-mill, and a saw-mill. The heads used are 22, 18, 20, 16, and 20 feet, respectively, and the total power is 214 horse-power.

Florida.—There is one grist-mill at Florida using about 30 horse-power.

Defiance.—At Defiance are two flour- and grist-mills, a woolen-mill, a planing-mill, and machine-works. The heads used are 11½, 14, 17, 16, and 7 feet, respectively, and the total power used is about 214 horse-power.

Junction.—At Junction is a grist-mill, with 21 feet head and 12 horse-power.

From Junction west to Fort Wayne there is no power used on the canal, and the only use made of it is for local traffic. It is much run down. In Indiana the canal was sold to a private company and is going to ruin.

Fort Wayne.—At Fort Wayne there are two flour- and grist-mills and a woolen-mill. The heads are 16, 16, and 17 feet, respectively, and the total power now used is 170 horse-power. One of the flouring-mills does not use the power, because of litigation. On the branch of the canal running south from Defiance there is, according to the census returns, about 670 horse-power used north of the water-shed line, by twenty establishments, chiefly flour- and grist-mills.

PORTAGE RIVER.

The Portage river drains 695 square miles, and flows northeast into lake Erie just north of Sandusky bay. The region drained by it is the eastern end of what was known in the early years of the state as the Black swamp, a strip extending through the northwestern end of Ohio and into Indiana. Formerly there were several mills on the river, but since the draining of the land the river wastes to almost nothing during a dry season, and all these mills are discontinued. The upper branches of the river have been deepened and turned into a series of ditches by the county authorities, also the waters of Hancock and Putnam counties have been diked off and turned into the Maumee to make the land suitable for farming.

SANDUSKY RIVER.

There is slack-water to Fremont, the head of Sandusky bay. Above Fremont the fall is 75 feet up to Tiffin, 4 feet per mile. It is on this stretch of 18 miles that nearly all the mills are situated, the fall not being so much above Tiffin. There are no lakes, but several creeks tend to keep up the flow. Several enter just above Fort Seneca, and make the river especially steady at that point.

The stream presents the average features as regards freshets, being perhaps rather flashy. It has gone down to 10 horse-power under 8 feet head, and up to 1,000 horse-power under the same head. The average power of ordinary low water under 9 feet head is 45 horse-power. The area drained is 1,457 square miles.

At Tiffin, below the railroad bridge, the bed is very rocky and there is considerable fall. The channel here is about 200 feet wide, and when visited the stream was low and flowed in several small channels between the rocks. The banks are high at Tiffin and restrain the ponds to the river-bed. There is no unimproved fall between Fremont and Tiffin, one level backing up nearly to the foot of the other. The bed of the river is mostly rock.

Utilized power.—From the lowest power at Fremont the utilized powers are as follows, in ascending order: At Fremont is a flour- and grist-mill, with 6½ feet head and about 40 horse-power. Above is a power of 15 feet head and 70 horse-power, running a tannery, a woolen factory, and a flour- and grist-mill. Next a flour- and grist-mill with 17 feet head and 40 horse-power used. A saw-mill with 8 feet head and 40 horse-power. Near Fort Seneca a power with 9 feet fall and 60 horse-power, running a flour- and grist-mill and a saw-mill. Above this is a saw-mill with 14 feet and about 80 horse-power. Then a power of 24 feet head, 150 available horse-power, of which half is used by a flour- and grist-mill and a saw-mill. Then a flour- and grist-mill, using about 50 horse-power under 14 feet head. Next a flour- and grist-mill, using 50 horse-power under 7 feet head.

At Tiffin there is a power with 7 feet head available, and all is used; 40 horse-power is available on the average, and runs a grist-mill and a saw-mill which can run full capacity eight months of the year.

The dam is built of logs and frame, and is situated just at the rocky ledge already mentioned. The banks are high, and the pond is 200 feet wide by 1½ mile long.

The Tiffin water-works are situated in the town, and pump water from the river.

The fall is 10 feet, and about 60 horse-power is available. There is liability of an insufficiency of water to do the pumping, and steam is used to aid. A grist-mill on the same pond runs when there is surplus water.

The next power has 7 feet head. The pond backs up 7 miles, and in one place spreads to some extent. When the gates are shut for three or four days the supply below is small. There are a flour- and grist-mill and a saw-mill, using about 35 horse-power during low water. There is only one mill above this and below Upper Sandusky. It is a grist-mill, with 5 feet fall and 20 or 25 horse-power. There are no mills of any importance at or above Upper Sandusky.

From the Sandusky river east to the Cuyahoga there are several rivers, as the Huron, Vermilion, Black, and Rocky rivers, which are small, draining 300 or 400 square miles, and which run a few small mills doing custom work, and are not specially important.

CUYAHOGA RIVER.

General description.—This is the largest river of northern Ohio east of the Maumee. The valley is the result of erosion, as with all the streams of the region, but here the action has been enough to leave hills 200 feet or more in height, which at places give an element of wildness to the quiet beauty of Ohio scenery. The river rises in Chardon, Geauga county, 20 miles from the mouth at Cleveland, and, yet it flows 75 miles, and, if all the windings were measured, at least 100 miles, well deserving the Indian name, Cuyahoga—"Crooked river".

The course is south-southwest to within 2 miles of Akron, and then it sweeps sharp around and flows northwest to lake Erie; it is extremely winding. In one place a straight line 5 miles long would touch two points on the river 12 miles apart by the channel. Above Hiram rapids a ledge of rock stretches across the stream and backs the water into Chardon township, making it a great underground reservoir with many lakes and swamps. These and the springs maintain a somewhat steady flow. In Portage county are at least nine lakes, and many are in Geauga county. The river is larger in its upper part than near its mouth, because fed into the Ohio canal. At Peninsula it averages 130 feet wide and at Cuyahoga Falls 70 feet wide, but near the mouth it is in many places not more than 20 feet wide and 1 foot deep. The flow at Cuyahoga Falls is about 67 cubic feet per second during ordinary low water. The rise due to freshets is 8 feet at Peninsula and 5 feet at Cuyahoga Falls.

There is no special liability to ice-gorges except at the mouth, where there is slight danger of flooding the Cleveland flats and doing great damage, as in 1860, when the flats were covered with 4 feet depth of water. The river was declared navigable by the government, but is used now only for water-power and for feeding the canal. The valley is cut through the Carboniferous conglomerate, Waverly shales, and Erie shales.

At the bend at Akron the basin is very large. The falls were once in Cuyahoga county, and have since worn their way back to their present position above Akron. The plane at Cuyahoga Falls is about on the level of the hill-crests about Akron. The valley consists largely of a series of basins, the hills separating and again approaching the stream. The bottom-lands are good, but much cut up. The staple on them is corn. Back from the river wheat is raised. On the hills is oak, a little beech and maple, and some fir.

Abstract of levels.—Fall from Hiram rapids (head of power) to lake-level is approximately 525 feet, 455 feet between the lake and the upper pond at Cuyahoga Falls and 70 feet above. Nearly 194 feet of the 455 is compressed within 2 miles at Cuyahoga Falls; hence the foot of the falls is 261 feet above the lake. The total fall utilized by manufactories is about 150 feet. There are 43 feet total of old abandoned power, and about 8 feet used by the canal.

The unimproved fall is about 360 feet. Of this, part is poorly located and part is awaiting capital; 120 feet is at Cuyahoga Falls.

DESCRIPTION OF THE WATER-POWERS.

For 3 miles the river is dredged to admit of navigation, and is 100 to 200 feet wide. The Ohio canal is then locked into it. Above, the immediate banks are from 4 to 6 feet high, clay, and vertical, with overhanging sods in many places, showing that the river is eroding them. The bed is mud or gravel and stones. A little below Brocksville is Packsaddle narrows, where the valley is very narrow and there is considerable fall.

Brocksville.—At Brocksville is a pond feeding the canal, with a head of 4 feet. There are no mills. The bed is flat ledge-rock.

Boston.—At Boston is the first dam built below Cuyahoga Falls. It was erected in 1821. A log dam now replaces the old one. It is a spur dam with eight tiers of logs. There is a flour- and grist-mill on the east bank of the river, and a saw-mill is also run by the same power. The bed is rock, and the earth-banks are 7 or 8 feet high. The dam is about 150 feet long, and the pond backs half a mile up stream. Its level is 90 feet above the lake. Below Boston the bed is largely made up of gravelly earth, and this, together with the small volume of flow below the canal dam, makes the powers inferior.

Peninsula.—The town of Peninsula takes its name from the necks formed by the bends of the river. At the upper and principal one the river swept around almost in a circle one-third of a mile in diameter, embracing a flat of about 20 acres. This bend has been cut off by the railroad. The channel returned to within 16 feet of itself, and an old resident said he had seen the two currents rushing in opposite directions in high water, and separated only by a narrow strip of land 2 or 3 feet wide. The neck rose 10 feet above the water, and the difference in the level on the two sides was 6 feet. When the Valley railroad was built, in order to avoid erecting two bridges within less than half a mile distance, the neck was cut down and the river turned abruptly to the west, thus leaving the channel dry. Previously to this the Peninsula flouring-mills, situated right at the neck, had merely thrown a line of logs across the channel, raising the level 1 foot, and thus obtained 7 feet head. The head-race is tunneled through the blue shale. When the neck was cut the head of 7 feet was maintained by merely sinking two sill-pieces into the bed of the river and covering them with planking. The canal crosses the river below the mill by a bridge, and is locked down by a lock of 10 feet lift to the flat. Then it bends to the west and follows the river around the hill, which is part of the "second peninsula". Part way around this hill the canal is fed from the river by a dam with 4 feet rise. Above the "neck" is the upper dam of Peninsula. There are two saw-mills and a planing-mill using the power, which has 8 feet head.

The total fall utilized for power at Peninsula is 15 feet. There is sufficient power for the requirements except on Mondays. The reason of this is that the mills at Cuyahoga Falls and above shut down on Saturdays. There is considerable unimproved power, especially below the neck, where the river falls rapidly, and none of this power is utilized. Just above the railroad bridge at the "third peninsula" there is at least 6 feet fall available. At one time the water was taken across the peninsula by means of a race to a grist-mill at Buttermilk falls, but this is disused. The upper pond at Peninsula is 40 feet above the Boston pond and 130 feet above the lake-level. The bed is firm and rocky to half a mile above Peninsula, but above that to Cuyahoga Falls the bed is poor for dams, and there are no mills on the stream until the latter place is reached, although there is considerable fall.

The Valley Forge property.—The rise from the upper pond at Peninsula to the foot of the Valley Forge property is 67 feet, and there is 25 feet fall now lying idle. In early days iron ore was reduced at the place. The situation is good for dams, and a pond is practicable. The Little Cuyahoga, entering at Akron, is the chief tributary, but is of little importance for water-power.

CUYAHOGA FALLS.

Cuyahoga falls are situated in Summit county, just above where the river takes its bend to the northwest. The drainage area above the village is 328 square miles. In about 2 miles the river falls 194 feet in a succession of rapids and cascades. At the upper part the river flows at the level of the slightly rolling country, and from there it has cut its way down through the sandstone and shale of the Coal Measures, through the conglomerate, and into the Cuyahoga shale of the Waverly. At one time the falls were at the north line of the county, and probably had a vertical fall of 200 feet.

The village of Cuyahoga Falls is at the upper end of the glen. The Cleveland, Zanesville, and Cincinnati railroad passes along the east bank close to the cliffs, which, at the High bridge, rise 100 feet. In the village are five dams, supplying some ten or twelve mills, machine-shops, chain-works, etc., with power. These five levels take 74 feet of the fall, leaving 120 feet of unimproved fall below them. Between the levels there is no unimproved fall of any consequence.

The Millbank property.—Ascending the stream, the first power met above Valley Forge is included in the Millbank property, belonging to Mr. Millbank, a capitalist of New York city. This includes 1½ mile below the Hinds dam, and embraces the wild and beautiful scenery of the falls. At Big falls, 25 feet high, the water tumbles over a succession of sandstone strata underlaid by soft shale. Above Big falls the river is placid for some distance, and makes a graceful sweep around to the northeast, with a heavily wooded flat in the bend of 5 or 8 acres area. Above the bend the slope increases rapidly, the banks approach each other, and huge bowlders and masses of rock obstruct the flow. This reaches the climax at a place called "the gorge", where the passage is so narrowed that the river is literally forced up on edge and foams between the huge rocks with great force. Above this point the channel widens somewhat and the current is less impetuous, although still very rapid. From there up to High bridge the banks, which have been very steep and rocky, rise in bold cliffs, especially on the east side, some 100 feet in height. The rock is the new red sandstone, which would yield a fair quality of building-stone. It is coarser and a lighter brown than the Connecticut brownstone. The cliffs show, also, a section of the Carboniferous conglomerate. A pleasure-resort company has taken possession of the glen.

From the overhanging eastern cliffs 100 feet above, springs of clear sparkling water trickle over in drops which fall like the first drops of a shower into the still, dark basin below; lighted by the afternoon sun they glisten like diamonds. Standing on the hill opposite the bend of the river, a beautiful view is obtained down the valley of the hills wooded from the top to where they meet the river, while up the river is the glen, and the opposite bank is darkened by the heavy hemlock foliage.

From the foot of the Millbank property to Big falls is 40 feet rise, at Big falls 25 feet, and from there to the bend there is a rise of 10 feet. By building a dam 10 feet high at Big falls there would be 35 feet head available, and 265 horse-power during ordinary low water. The power could be transmitted by wire rope to near the railroad, or utilized on the spot if the proposed wagon-road is built. The dam would be not over 150 feet long, and the pond would overflow slightly if at all. From the bend through the gorge the rise is 24 feet, and to the foot of Hinds' dam it is 20 feet more. A short distance above the bend a dam could readily be constructed, but the best place is directly in the gorge, where the position of the rocks is such as to make excellent abutments for the dam, and the power could be transmitted along and up the banks by wire rope. The dam would be not over 50 feet long, and all the fall up to the Hinds level could be utilized. If the Millbank property were fully developed there would be 980 horse-power available with ordinary low water.

The bed of the stream is rocky and firm and the banks are good, as just described, and ponds would not spread. Right at hand is an unlimited supply of good building-stone. The one disadvantage is the inconvenience of access in some places, but even this can be readily overcome. There seems to be no reason why the development of the power should not be attended with success. Mr. Millbank is a wealthy man who has felt no necessity of using the resources of the place, and for this reason, apparently, the power has remained idle.

In the year 1835 a company called the Portage Canal and Manufacturing Company bought a tract of land in the vicinity of Akron with the intention of building up a city, but seemingly with the more immediate intention of selling lots. As an accessory to the scheme the company bought what is now the Millbank property, intending to run the water off by a race 6 miles long to their city, and utilize it there for manufacturing purposes with about 180 feet head. It is now thought that the object was to make a sensation in the midst of which to sell the lots; certain it is that the race as constructed was ridiculously small for the purpose. Where examined near the head, it could not have been over 15 feet wide, and probably averaged less. The dam was built a short distance below the Hinds dam, and the race ran along the east bank in the shale underlying the conglomerate. This shale slacks on exposure and will not hold water. The race as well as the city was a total failure, and the ruined embankment now forms a convenient promenade for pleasure-seekers.

The Hinds level.—The Hinds dam is situated immediately above the Millbank property, and from this point up all the fall is utilized. The dam is a frame 100 feet long, built of triangular sets. From it a flume runs down the west bank, 300 feet long and 6 by 6 feet in section, built of 2-inch pine plank. At its foot is a 35-inch turbine, whose shaft extends 80 feet up the cliff in a vertical "husk" to the flour-mill. The head is 14 feet, and 100 horse-power is available.

Levels above Hinds' dam.—Above Hinds' dam are four levels, with the following heads, in order: 16½ feet, 18 feet, 10 feet, and 15 feet. At these levels there are twelve establishments using 575 horse-power total, according to the census returns. They consist of one flour-mill, two paper-mills, a wire-works, a sewer-pipe manufactory, a bolt- and nut-works, foundery, and machine-shops. Practically, all the available power is taken up, as, with the estimated ordinary low flow of 67 cubic feet per second, the total power is about 450 theoretical horse-power. The dams are like the Hinds dam, except the upper one, which is of peculiar construction. It is built of hewed timber 12 inches square, laid close in two concentric arcs, and keyed together with cross-pieces of scantling 2 feet long. Above this dam there is a stone filling.

Munroe falls.—Munroe falls, 2 miles up stream, is the first available power above Cuyahoga Falls. There is 10 feet head utilized by a paper-mill, which claims 115 horse-power. The dam is an arched timber dam 100 feet long.

Kent.—At Kent is the next available power, and it has 26 feet head. The dam is a nearly semicircular arch of stone 2½ feet thick, and filled in with stone above. The chord is 75 feet. The bed and banks are rocky and the banks high, so that the pond near the dam is scarcely 40 feet wide; it runs back 5 miles. There is a race on each bank. On the right bank is the Kent alpaca mill, using an overshot wheel of 17 feet diameter and 19 feet face, capable of 50 horse-power. On the opposite bank is a flouring-mill, claiming in the census returns 100 horse-power under 21 feet head.

The river above Kent.—Above Kent there are four places at which power is used. At Sheffield there is a grist-mill using 25 horse-power, and a stone- and earthen-ware establishment using 8 horse-power. At Mantua is a grist-mill using 25 horse-power. At Hiram rapids there is an available fall of 10 feet. Above the rapids are two grist-mills using 12 and 30 horse-power under 13 and 14 feet head, respectively.

THE OHIO CANAL FROM CLEVELAND TO THE SUMMIT.

This canal runs from lake Erie to the Ohio at the mouth of the Scioto river. It is in a better condition than the Miami and Erie canal. The first feeding-place above Cleveland is at Seventeen-Mile lock, 17 miles from Cleveland. There are three establishments using power between Cleveland and Peninsula—the Austin Powder Company,

$3\frac{1}{2}$ miles up, a flour-mill 14 miles above Cleveland, and a second flour-mill 19 miles above Cleveland. At Akron there are five powers used from the canal by a flouring-mill, a paper-mill, a planing-mill, pump-works, and rubber-works. Beyond the summit level in the Ohio basin there are several mills. The branch running east past Cuyahoga Falls was bought by the railroad and closed up.

THE HYDRAULIC CANAL OF AKRON.

Akron is an extensive manufacturing center, and most of the power used is steam-power; the State canal and this hydraulic canal represent the water-power of the city.

The Hydraulic Canal Company was organized in 1839, consisting of the owners of the five mills now using the power, viz, the Cascade, Etna, City, Allen, and Stone mills. The power is obtained by tapping Springfield and Fritche's lakes, each about 1 mile long by half a mile wide, and carrying the water to the city by a canal. Part of the distance the channel of the Little Cuyahoga is used. Each of the lakes is tapped by a 24-inch pipe running up through the bed, and leading off with about 6 feet fall a distance of nearly 1,300 feet to the canal. Springfield lake can be drawn down 6 feet and the other 8 feet. Although there are these two reservoirs the supply gets low in dry seasons, and several of the mills supplement the power with steam. There are six mills on the canal, all near where it empties into the Ohio canal, but one of them, the Turner mill, now uses steam altogether. All are flouring-mills but the Turner mill, which manufactures oat-meal. Passing down the canal they are as follows: The Stone mill, with 27 feet head and averaging 75 horse-power; the power is unsteady and they use steam. The Turner mill, with 5 feet head, owing to the canal lock (not using water-power now). The Allen mill, with 18 feet head and 43 horse-power; steam is always used to aid the water-power. The City mill, with 25 feet head, and a wheel rated at 100 horse-power; they can run at their full capacity seven or eight months of the year. The Etna mill, with 20 feet fall and a wheel rated at 80 horse-power; they also use a 100 horse-power steam-engine. The Cascade mill, with 28 feet fall. These mills have much more machinery than can be run by the flow available from their drainage area, and it may almost be said that the water-power is used as an auxiliary to the steam-power.

THE GRAND RIVER.

The Chagrin river is a small stream having a few unimportant mills, and the next river to engage attention is the Grand.

This stream rises in Geauga county and flows north to within about 10 miles of lake Erie, and then bends 90 degrees and flows west some 20 miles, entering the lake near Painesville. The drainage area is 690 square miles. The chief tributary is Rock creek, which enters it from the east, about 2 miles above the bend. The river is an instance of the effect of clearing and draining the land; if it were a steady stream its ordinary low flow would probably be at least 50 cubic feet per second, but it has become so flashy as to be almost worthless for water-power. There is considerable fall in places, but sometimes the bed is almost dry. Formerly there were several mills, now mainly discontinued or using steam. The census returns show only three mills on the river, using 60, 60, and 20 horse-power, under 35, $7\frac{1}{2}$, and 8 feet head, respectively. Below Mesopotamia, in Trumbull county, the fall is slight to the bend, and a dam is said to back the water up stream for a distance of 20 miles.

WATER-POWER EAST TO THE NIAGARA RIVER.

There are no streams of much importance for water-power east of the Cuyahoga river to the foot of lake Erie. Ashtabula, Mud, and Cataraugus creeks, etc., are small and of little importance for water-power.

TONAWANDA CREEK.

Tonawanda creek, entering the Niagara river at Tonawanda above the falls, is larger than Cataraugus creek, but is unimportant for water-power, not only on account of its size, but especially because flashy. In early times it was more steady, and there were many small mills on its upper part, but now they are unused. At the mouth is a canal dam giving slack-water navigation for the Erie canal. The head is $4\frac{1}{2}$ feet and the pond is 12 miles long. There is a power 15 miles up the stream at a place called Rapids, but this is within the Indian reservation. At Batavia, also, there is some fall.

THE ERIE CANAL AT BLACK ROCK.

The Erie canal enters Tonawanda creek at Pendleton some 12 miles above the mouth, and then by the slack-water navigation referred to the boats reach Tonawanda. From there a short canal extends along the bank of the Niagara river to Black Rock, about 3 miles below Buffalo, and there it is locked into the Niagara river. At Black Rock there are five good-sized flouring-mills using the power, which has about 5 feet head. The supply of water is constant, but some trouble is experienced, especially by the lower mills, from the water backing up on the wheels, owing to the rise in the river. This is caused by the wind, and is from 2 to $3\frac{1}{2}$ feet, as an extreme.

THE WATER-POWER OF NIAGARA RIVER AND FALLS.

Because of the importance of the Niagara water-power and the great impetus which manufacturing has recently taken at the falls, a second and special visit was made to the place in August, 1882, and the following report relates to the condition of the power at that time:

The system of fresh-water lakes which drains into the Atlantic through the Saint Lawrence river extends half way across the continent to the Pacific, and from the Saint Louis river at the head of lake Superior to the head of the Saint Lawrence, includes thousands of square miles within its basin. The lakes Superior and Michigan drain through lake Huron into lake Erie, and from the latter the combined volume of water pours into lake Ontario through the Niagara river.

The Niagara, with a volume nearly half as great as the Mississippi, has only a short course of 37 miles in a direction of a little west of north; but in order to reach the level of lake Ontario it has to descend 333 feet, and to its immense flood falling all this height within so short a distance is due the grand falls with their rapids. The river makes a vertical plunge of about 160 feet.

GENERAL DESCRIPTION OF THE LOCALITY.

The river forms the boundary between Canada and the state of New York. Between lake Erie and the falls it divides into two channels around Grand island, which is about 10 miles long and 4 or 5 miles wide. In passing around this island the eastern channel bends to the westward, and for the 3 miles from the foot of the island to the falls, the course of the river is west.

At the falls, which are 23 miles below lake Erie, measured along the east channel, the river is divided into two channels by Goat island, which, beginning at the falls, runs up stream 3,000 feet, and is 1,100 to 1,200 feet wide. The rapids begin at the head of Goat island and continue to the falls. The channel on the Canada side forms the Horseshoe falls, 158 feet high and 2,400 feet wide, and the other the American fall, 167 feet high and 1,000 feet wide. One mile above Goat island the river is over 6,000 feet wide. At the head of the island, the American channel is only 500 feet across, and the other channel is 3,200 feet in width, probably taking seven- or eight-tenths of the total flow of the river; hence the Horseshoe fall is much the more important of the two.

Immediately at the falls the river turns directly at right angles and flows north, and here begins the gorge which characterizes it, to the village of Lewiston, 7 miles below, where are the Lewiston heights; the river, emerging from them upon the plain below, flows the remaining 7 or 8 miles to lake Ontario. Just below the falls, the gorge is 1,100 to 1,200 feet wide from brink to brink, and the river is 800 to 900 feet wide. The banks rise in vertical cliffs 210 feet above the water, with a talus at the foot, and the river reaches a maximum depth of 189 feet. Owing to the bend of the river, the gorge may be said to begin at the Horseshoe fall, and the American fall enters over the eastern cliff.

Two miles below the falls are the Whirlpool rapids, where the river contracts to 400 feet in width, and farther below is a point where it is only 300 feet across.

The country through which the Niagara flows may be roughly described as a plateau separated from the low land bordering lake Ontario by the terrace called Lewiston heights, which extends far to the east in the state of New York, and marks an old shore-line of lake Ontario.

When the lake-level lowered and this outlet of lake Erie began to fall over Lewiston heights, it speedily wore its way through the thin covering of drift forming the river terraces now seen along its course, and attacked the layer of Niagara limestone which made its bed. The Niagara limestone is underlaid by a thin stratum of very soft shale, and below this are strata of varying hardness, and the result was, that as the hard rock was undermined by the action of the water it fell and left a constantly receding vertical face over which the river passed.

Gradually the falls receded up stream, varying in height and form as the slight dip of the strata changed the altitude of the hard layers, leaving below the deep narrow gorge, while above, the river flowed at the surface of the country or had only cut shallow terraces through the drift. The present time finds the falls opposite the village of Niagara Falls, 7 miles on their course toward the threatened draining of lake Erie.

Above the falls the river flows over solid rock, which is destined to be broken and ground by the relentless fury of the flood. Its banks are low, scarcely more than clay rim-banks rising above the surface of the water, but as the falls recede the banks will probably form a continuation of the terraces which now border the gorge.

Goat island is a portion of the country which has been left by the river, and will probably continue until the recession of the Horseshoe fall drains the American channel and joins it to the mainland in the far distant future.

The surface of the island, like the shores of the river, is very slightly elevated above the water at the head of the rapids; but while it maintains a level surface the rapid descent of the river makes its sides precipitous bluffs near the falls.

MAP OF NIAGARA FALLS

Reproduced from the Map of the U.S. Lake Survey.

The Whirlpool rapids are caused by a tendency to a repetition of the circumstances which make the falls; a much harder stratum of rock outcrops in the bed of the river at that place, and hence the channel is not worn so deep, and it is the rush of the great volume of water in endeavoring to pass this shallow place that causes the tremendous surges of the rapids.

POWER OF THE NIAGARA RIVER.

Although it is difficult to imagine that the estimate of the total power of the Niagara river will ever be of practical importance, yet, the data being given, it is a matter of very easy calculation.

According to gaugings made by the United States engineers, the average flow of the river above the falls is found to be 10,000,000 cubic feet per minute, 166,600 cubic feet per second.

The fall of the river in the 20 miles from its head at Buffalo to 3 miles above the falls is 20 feet. From this point to the brink the total fall is 53 feet, of which nearly all is comprised in four terraces of the following heights above the brink of the falls: First terrace, 14.75 feet; second terrace, 24.09 feet; third terrace, 32.42 feet; fourth terrace, 39.79 feet (Blackwell's survey, 1842). Goat island has the same general level as the fourth terrace.

The American fall, according to Blackwell's survey, is 167.7 feet high, and the Horseshoe fall is 158.5 feet high. From the foot of the falls to Lewiston the descent is 98 feet, and from there the surface of the river falls 2 feet to lake Ontario.

The following table gives the theoretical power of the river in falling from one lake to the other:

Portion of river.	Fall in feet.	Theoretical horse-power.
Lake Erie to above the rapids	20	378, 00
The rapids	53	1, 001, 700
The falls	160	3, 024, 100
The falls to Lewiston	98	1, 852, 300
Lewiston to lake Ontario	2	37, 800
Total	333	6, 294, 000

Of this 6,000,000 horse-power, all but about 400,000 is between the head of the rapids and the foot of the gorge, and 4,000,000 horse-power are expended within a distance of less than a mile at the falls.

Fluctuations in flow.—With the immense storage-reservoirs above, the Niagara river is very steady in its flow, but it has been known to vary as much as 33 per cent. in 48 hours; this is due to the wind on lake Erie. If the wind blows strong from the northeast for some time, it lowers the eastern end of the lake, and then if it veers around suddenly into the opposite direction, the maximum flow is observed on the river. The extreme limits of variation in the depth of the river above the falls is 3½ feet, but these limits are very rarely reached; the ordinary variation is hardly more than 1 foot. Below the falls the level varies 15 feet, because of the diminished width of the channel.

Variations in the lake-level.—There are variations in the levels of the lake, and hence in the flow of the Niagara river, which can not be attributed to variation in the rainfall, or to the wind, and are not satisfactorily accounted for. Sudden tides occur, amounting in some instances to 3 or 4 feet in height, and it is claimed that there are periodical changes extending over several years. Mr. Charles Rhodes, of Oswego, New York, in a publication on the subject states:

> In April, 1873, after eighteen months of very low water, lake Ontario rose 2½ feet in about twenty days. When it is considered that the whole inflow of the Niagara during that time would scarcely more than fill the lake to that extent, or if the flow of the Saint Lawrence were entirely stopped for a couple of weeks it would only raise the lake to that extent, the magnitude of the change may be appreciated, but can hardly be accounted for.

He argues against the theory of a subterranean channel between the lakes. Mr. Rhodes is inclined to attribute some of the changes in level to inequality in the atmospheric pressure.

USE OF POWER AT NIAGARA FALLS.

There have been men from the early years of the country who have realized the value of the power, and have anticipated for it an era of usefulness, which is fortunately in no wise incompatible with the much-needed restoration of the natural beauty of the place.

In the year 1678 a portion of one of La Salle's exploring expeditions built their huts some 5 miles above the falls, and there is a description of the impression produced by the falls upon the explorers, written by Father Hennepin, a priest who accompanied the party, and who acted in the capacity of historian.

For nearly a century after this visit of the French there was, so far as can be learned, no attempt made to make use of the water-power, and it was not until 1750 that a wheel was built.

HISTORICAL SKETCH OF THE USE OF THE POWER.

The following is an abstract of the history of the development of the water-power interests of Niagara Falls, as obtained through the courtesy of Mr. Albert Porter, an old resident of the place. In order to make it intelligible it is well to give a brief account of the improvements as they exist at present:

The village of Niagara Falls is situated in the angle at the falls where the river bends; it extends along the New York shore nearly a mile above the falls, and also some distance down the gorge. In 1870 the population was 3,006, and in 1880 it was 3,320. The land on which the village is built is quite level, and the variation in altitude is only about 40 feet. The contour is such that races could be very readily constructed along the rapids, using their fall; but the crowning feature of the place in this respect is that the level nature of the land permits the excavation of canals through the village, across the bend, striking the river bank below the falls. This is precisely what has been done. Starting above the village, at what is called, by some, Port Day, an hydraulic canal passes across the bend, and ends in a basin 600 feet long, running parallel with the cliff 2,400 feet below the American fall. Along this basin mills are situated. There are also two races along the rapids; the upper race, starting opposite the head of Goat island, and the lower race, beginning about half way down the length of the rapids and extending to Prospect park, which occupies the angle immediately at the American fall.

On Bath island, which is in the American channel, a little below the center of the rapids, there is a paper-mill obtaining a head by means of wing-dams; and this concludes the list of developments of the water-power of the falls, with the exception of a wheel used on the Canadian side for pumping water for the inhabitants.

As early as 1688 La Salle built the first stockade at Niagara. In 1725 it was greatly enlarged, the stone buildings now standing were erected, and a permanent fort was made.

The first recorded use of the water-power was the erecting of a saw-mill, probably in 1725, to supply lumber for the use of fort Niagara. This was built just above the site of Witmer's mill, which stands near the head of the upper race. The entire region remained in the hands of the French until the war with England. During the war the mill was destroyed, but was afterward rebuilt by the British when they gained control of the region.

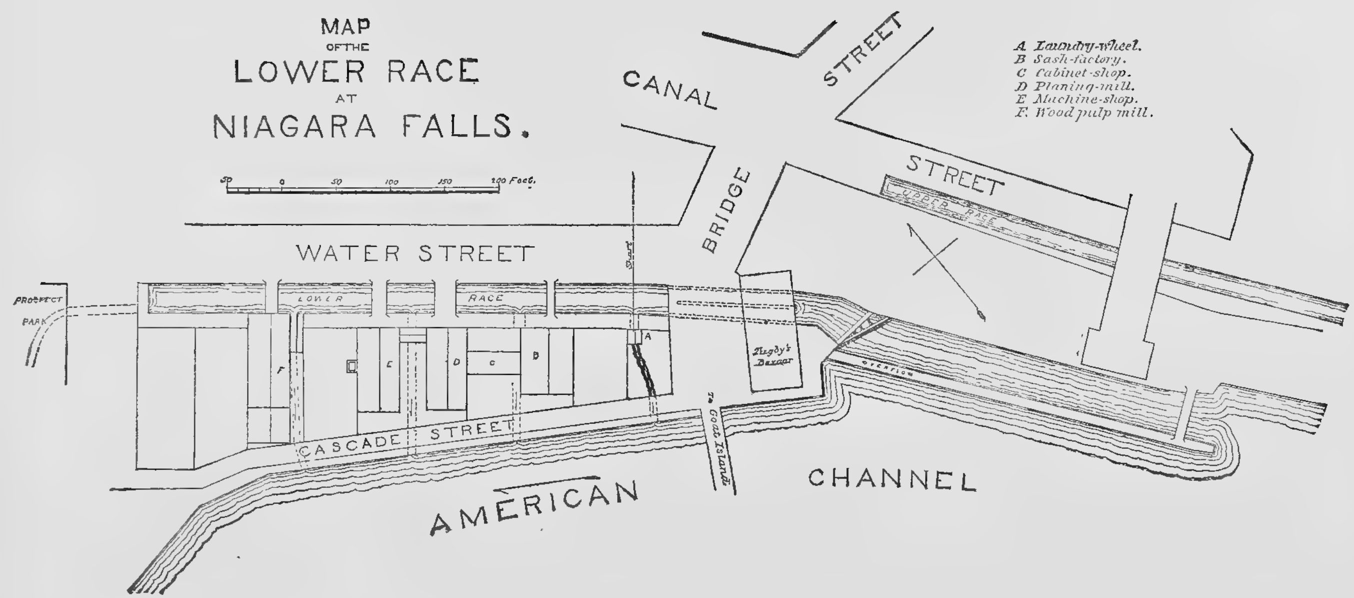
Passing over the intervening time to the present century, during which no further use was made of the power, we find that, through the disputes of the colonies concerning their boundaries, New York finally came into possession of a tract 1 mile wide along the entire length of the east side of the Niagara river. This was surveyed into farms, water-lots, etc., and sold, and Augustus and Peter B. Porter and Benjamin Barton bought a very large tract in the vicinity of Niagara Falls. To a considerable extent this yet remains in the possession of the heirs of Augustus Porter, who had great faith in the value of the place for manufacturing, and gave the village the name of Manchester. He built the upper race in 1805, extending it only a short distance below the site of Witmer's mill, and erected a saw-mill, and the next year a grist-mill was built. About that time was started what has grown to be the present lower race, and from it were run a woolen factory, a carding-mill, and a tannery. In the war of 1812 the village was entirely destroyed, and the power was not again used until 1816. Mr. Porter then rebuilt the grist-mill, placing it just above the site of the Witmer mill, where the old building is still standing. In 1822 he built on a much larger scale, and the building, now known as the Witmer mill, is still in use.

In 1823 a paper-mill was built on the lower race, and three years after was converted to other uses. Various other industries were started on the lower race, a forge, furnace, machine-shop, and pail factory at an early day, and others of more recent date. In 1826 A. H. Porter and H. W. Clark built a larger paper-mill on Bath island, where the industry yet exists, but in other hands.

In 1847 Augustus Porter, after having a survey made, published a proposal inviting capitalists to construct a canal along the site of the present hydraulic canal, estimating that power for sixty run of stone could be obtained with a cost of $30,000. Nothing was accomplished until 1852, when on the 24th of December his heirs—Mr. Porter being deceased—made a contract with Walter Bryant, of Boston, Massachusetts, whereby, on condition of the canal being constructed, there were to be conveyed to him 100 feet right of way for the canal, and 75 acres of mill-sites along the river below the falls. In 1853 Mr. Bryant organized the Niagara Falls Hydraulic Company, with Caleb S. Woodhull, ex-mayor of New York, as president and himself as agent. In 1854 the interests of this company were conveyed to John Miller, and the actual conveyance of the property was made to him by Mr. Porter's heirs.

From John Miller the property passed to Horace H. Day, a prominent eastern manufacturer, and his associates, and by their enterprise the canal was completed as it now exists. Then followed a long era of stagnation in the interests of the water-power, due partly to the distractions of the civil war, and partly to a somewhat visionary management. Finally the property passed into the hands of Mr. A. U. Chesbrough in 1874, and in the next year the first building was erected, a flouring-mill owned by Mr. C. B. Gaskill. Mr. Chesbrough sold his interests to Mr. J. F. Schoellkopf, of Buffalo, and the property is virtually under his control at present. The company is titled the "Niagara Falls Hydraulic Power and Manufacturing Company", of which Mr. Schoellkopf is president.

All the development of manufacturing on the basin has taken place since 1875, and the last three or four years have seen an immense increase. It is easy to see that the development of a most important manufacturing center rests with those capable of comprehending and improving the situation. Evidently the future manufacturing development depends upon the hydraulic canal, so far as existing works are concerned, rather than upon the two


MAP OF THE LOWER RACE AT NIAGARA FALLS.
50 0 50 100 150 200 Feet.
A Laundry-wheel.
B Sash-factory.
C Cabinet-shop.
D Planing-mill.
E Machine-shop.
F. Wood pulp mill.
CANAL STREET
BRIDGE STREET
WATER STREET
LOWER RACE
CASCADE STREET
PROSPECT PARK
To Goat Island
AMERICAN CHANNEL

races, which can never be enlarged to embrace a comprehensive improvement of the river, while the capabilities at the hydraulic basin are unrivaled. So far as can be learned there is no expectation of ever increasing materially the capacity of the races.

Favorable features of the water-power.—It is unnecessary to speak of the advantages of the place as regards unlimited supply of water and steadiness of flow. Winter and summer the river rushes on independent of freezing cold or of the dry heat of the summer months, the greatest variation being due only to the changing direction of the wind. By digging the races deep enough, the only effect of this on the power would be restricted to reducing the almost unlimited head obtainable, by 1, or in extreme cases 2 feet. Ice sometimes occasions trouble at the mills by clogging the racks. With a proper arrangement of breakwaters this is almost entirely warded off.

Regarding freighting facilities, there is the advantage of being on a through line between the West and the East. The New York Central, New York, Lake Erie and Western, Great Western, Canada Southern, and Rome, Watertown and Ogdensburg railroads all have lines to Niagara Falls or close connections.

All the utilized power, except at the basin, is some distance from any railroad track, and the products have to be hauled in wagons, but the tracks of the New York Central Railroad Company pass near the basin, and side-tracks are built there directly to the doors of the mills.

DESCRIPTION OF THE DIFFERENT POWERS.

PAPER-MILL ON BATH ISLAND.

The paper-mill on Bath island has been burnt three times since it was moved from the lower race. The last time occurred in 1881, and it has just been rebuilt in the most perfect manner, fire-proof, and with increased capacity. It produces over 10,000 pounds of printing-paper per day. The bridges connecting the mainland with Goat island touch the island, and the mill and office of the Niagara Falls Paper Manufacturing Company lie just below the road. There are three American turbines under 15 feet head of water, one giving 275 horse-power, and the others 65 horse-power each. This 410 horse-power is all that the size of the building demands.

The head is obtained by means of wing-walls, which extend 500 feet up stream and supply a large amount of water. The head of water does not vary more than 8 inches, depending on the direction of the wind on lake Erie. At the upper end of the wing-walls are several timber cribs sunk in the channel to ward off the ice, and the wing-walls are arranged with an overflow, so that what ice enters the race will pass out into the river. The ice sometimes lodges in the rapids above the opening of the race in blocks nearly 4 feet thick. In the old mill there were thirteen wheels supplied by this race. If the lease allowed the building of a dam to Goat island, and it were desired, the head could be very materially increased. There is no good opportunity for situating other mills on this race.

THE UPPER RACE.

The upper race starts near the head of the American channel, and extends 650 feet down to the waste-weir; from there it continues 800 feet farther, but much diminished in size, with stagnant water at the end of it. The upper portion has existed since 1805, as already described. The only buildings using the water of the race are the Cataract House laundry, near the lower end, and two bath-houses above. The laundry has a 48-inch turbine under 18 feet head of water.

There is a power so intimately connected with the upper race that it is best mentioned here, although to a certain extent independent. Behind the same breakwater which forms the head of the upper race a small race starts along the river-bank, with a stone wing-wall between it and the river, and runs 500 feet down the stream. At the foot is Witmer's grist-mill, with an average head of 6 feet, varying about 8 inches, according to the wind. The mill has four run of stone, and uses 60 to 70 horse-power. Some difficulty is experienced from ice choking the flume. Just above Witmer's mill is an old building which has been occasionally used as a sash-and-blind factory, and has a 60-inch wheel under 4½ feet head of water. A short distance below Witmer's mill is a small wheel at the river-bank, fed directly from the river, and used to pump water to a private residence. The descent of the rapids is so great at that point that a very short wing-wall gives a head of about 4 feet.

THE LOWER RACE.

The lower race is the scene of much more manufacturing than the upper race. It begins just opposite the Cataract house, overlapping the lower 300 feet of the upper race, and runs 1,000 feet along the river-bank. The first 400 feet are formed by a crib wing-wall built in the river; then the race passes through two stone culverts under Tugby's bazaar and the streets to the Goat Island bridge, and finally there is a length of 488 feet to Falls street. From the end of the race a small one, 4 or 5 feet wide and about 1 foot deep, passes under Falls street into Prospect park, and there it supplies 36 horse-power, under 12 feet head, for the electric lights and the inclined plane.

The lower race runs along Water street, and between it and Cascade street, which borders the river, are twenty water-lots, varying from 58 to 132 feet in depth. There are also two lots occupied by Tugby's bazaar. The race is 25 feet wide, and the normal depth is 6 feet. In the wing-wall portion it is about 40 feet wide. The lower 150 feet of

the wing-wall is an overflow, and at the lower end of this are the racks and gates for regulating the flow. All the utilized power is taken below Bridge street, and the buildings are situated on the lots mentioned. Wagons come to the rear from Cascade street, and bridges across the race connect them with Water street. The head of water available varies from about 7 feet at Tugby's building to 17 feet at the foot of the race.

The utilized power is as follows: On lot 2, below the bridge, is a tub-wheel, 6 feet in diameter, under 9 feet head, which furnishes power for the laundry of the International hotel by a 2½-inch shaft 300 feet long. On lots 5 and 6 is a sash factory, using a 5½-feet tub-wheel, under 11 feet head, giving 25 to 30 horse-power. On lots 7 and 8 is a cabinet-shop, using a similar power. Lots 9 and 10 are occupied by a planing-mill, with a turbine, under 12 feet head, giving 40 horse-power; and on lots 11 and 12 is a machine-shop, with about the same power. These two powers make use of the same bulkhead and tail-race. The next two lots are unoccupied, but upon lots 15 and 16 is a wood-pulp mill, the only very extensive industry on the race. It has two turbines, under an available head of 17 feet, and giving 400 horse-power usually. The remaining four lots are unoccupied, except by a hotel and other buildings.

There has been considerable difficulty between the different establishments on the race, owing to its inability to meet the demands upon it. When all the mills are running the head at the foot of the race is drawn down to nearly 14 feet. With its present capacity there is no power available for additional manufacturing, and, as it is, some of the powers owned are not represented at all in those used.

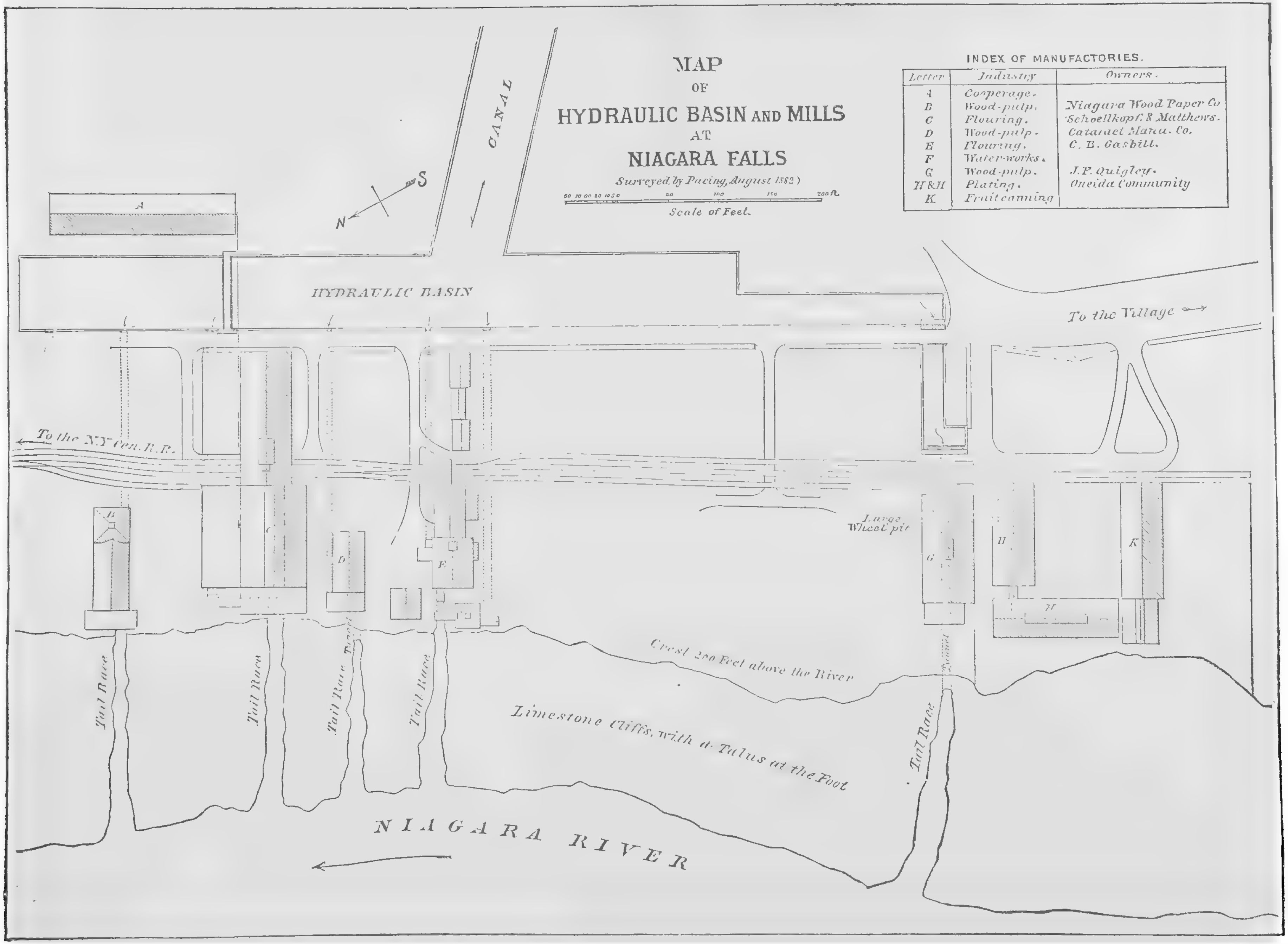
THE HYDRAULIC CANAL AND BASIN.

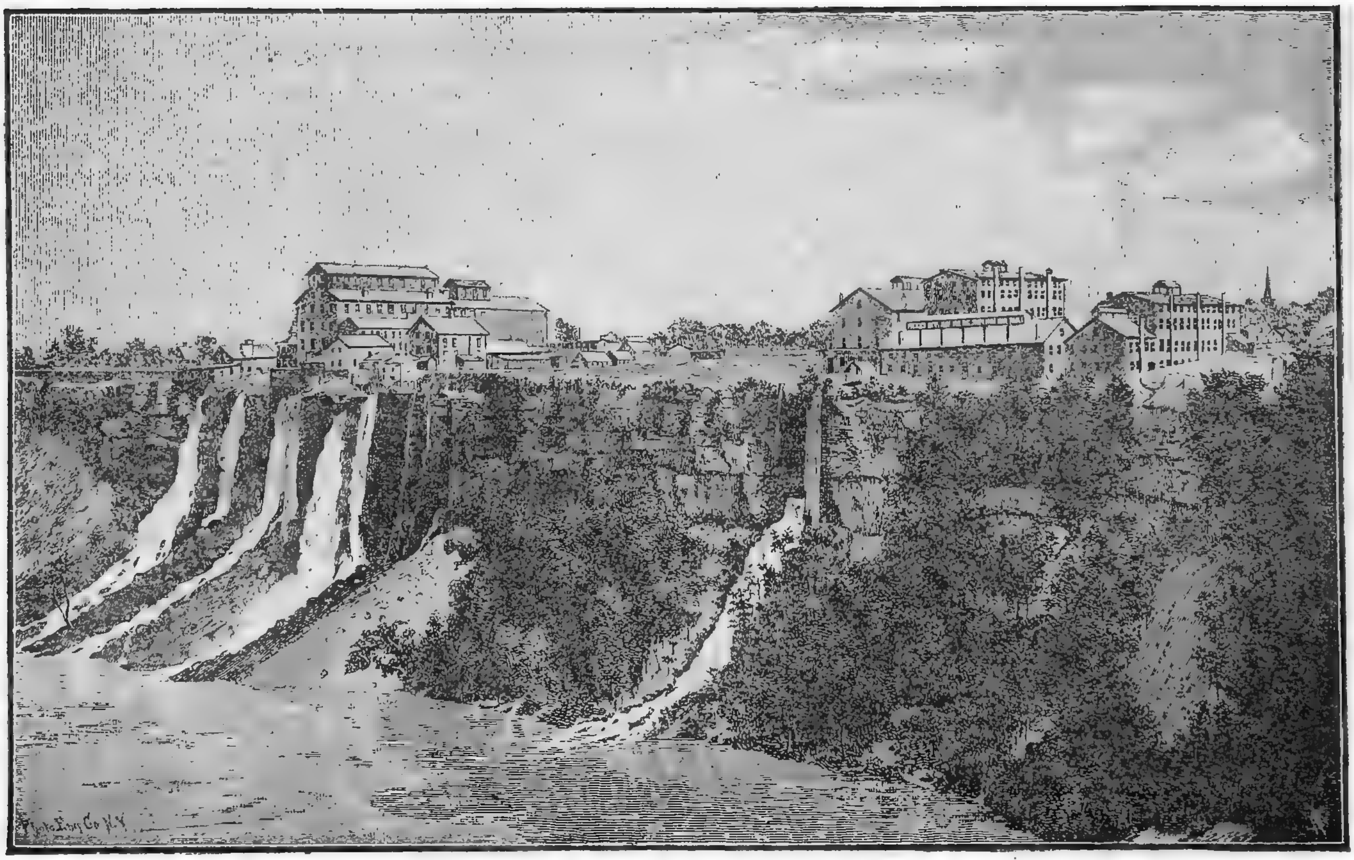
The brief account already given of the hydraulic canal and its history must serve to a certain extent to make its character understood. It is owned by the Niagara Falls Hydraulic Power and Manufacturing Company, of which Mr. J. F. Schoellkopf is president, Mr. Arthur Schoellkopf, secretary, and Mr. Benjamin Rhodes, of Niagara Falls, engineer. The canal occupies the most advantageous position along the river for an extensive development of the power. By cutting across the bend in the river it comes out at the cliff overlooking the gorge, and there is an extensive level tract where manufactories can be erected without interfering with the streets and buildings of the town, where railroad tracks are convenient, and where 210 feet head of water is available. After an inspection of the site it is difficult to conceive of any place more favorable for the development of a great water-power.

Below the covering of from 10 to 20 feet of drift are the solid layers of limestone, which are exposed in section in the sides of the gorge; and the plan pursued is to erect the buildings along the edge, sink a wheel-pit to any desired depth into the rock, and then tunnel out to the face of the cliff for a tail-race. The miniature waterfalls tumbling down the side of the gorge make a really beautiful sight. From the roofs of the mills a stone may be thrown into the river 300 feet below.

By the original grant the company owns 75 acres of land, extending along the river-front, and 100 feet right of way through the town along the line of the canal. The canal when completed did not fulfill the original requirement of 70 feet width, and remains unchanged; part is 70 feet wide, but a portion is excavated only to a width of 30 feet. It is largely cut through the hard limestone, and the deepest excavation is 20 to 25 feet below the surface of the ground. The depth of water is from 8 to 12 feet. The original intention was to furnish a navigable channel with a 30-foot tow-path along the side, but this has not been accomplished. It is practicable, and possibly the future will see boats passing back and forth between lake Erie and the basin in front of the mills. At the entrance to the canal the supply of water is regulated by two guard-locks, placed side by side, one of them usually closed. The length of the canal is 4,400 feet, and at a distance of about 300 feet from the edge of the cliff it enters the hydraulic basin, which is 70 feet wide and runs parallel with the river for a distance of 700 feet. On the level, 300 feet wide, between the basin and the cliff, the mills are situated. A road and sidewalk run along the river side of the basin, and about half way between the basin and the cliff are side-tracks of the New York Central railroad, running nearly parallel with them past all the manufactories. At the south or upper end of the basin there is an extension 30 feet wide for 200 feet, and from the end of this a 20-foot canal passes at right angles 100 feet toward the cliff, where it ends in a bulkhead 40 by 20 feet. All the wheels are set between the railroad and the river, and races run to them from the basin. There are six separate points at which wheels are placed, and some twelve different industries using the power.

Character of lease.—All the power in use is leased, with the exception of the power used by Mr. Schoellkopf, and two powers which were bought in the early days of the improvement. Because of the expense attending the excavating of separate races and tunnels for each mill, and thus to some extent deterring manufacturers from investing, the company has inaugurated the plan of excavating a large wheel-pit and tunnel as a center of power, around which to cluster industries, the shafts of the different buildings gearing upon the main shaft. One has already been made at the upper end of the basin. The company maintains the water-wheels and main shafting in running order, and manufacturers connect their machinery with it. In arrangements of this kind the charge is $10 per horse-power per annum. When heavy powers are required of from 500 to 1,000 horse-power, or more, the manufacturers supply their own water-wheels and appliances, and the company leases out the water under a head of 75 feet, charging $7 per horse-power for all powers up to 1,000 horse-power, and diminishing the rate for larger powers.


MAP
OF
HYDRAULIC BASIN AND MILLS
AT
NIAGARA FALLS
Surveyed by Pacing, August 1882)
Scale of Feet.
INDEX OF MANUFACTORIES.
Letter | Industry | Owners.
A | Cooperage. |
B | Wood-pulp. | Niagara Wood Paper Co
C | Flouring. | Schoellkopf & Matthews.
D | Wood-pulp. | Cataract Manu. Co.
E | Flouring. | C. B. Gaskill.
F | Water-works. |
G | Wood-pulp. | J. F. Quigley.
H & H | Plating. | Oneida Community
K | Fruitcanning |
CANAL
HYDRAULIC BASIN
To the Village
To the N.Y. Cen. R.R.
Large Wheel pit
Tail Race
Tail Race
Tail Race
Tail Race
Tail Race
Tunnel
Crest 200 Feet above the River
Limestone Cliffs, with a Talus at the Foot
NIAGARA RIVER
N
S



Character of the power.—As regards steadiness of the power, there is no reason for any fluctuation beyond that due to the direction of the wind on lake Erie. The running of all the wheels can not lower the level of the basin more than 6 inches, and with the great head used this is of no consequence. Mr. Arthur Schoellkopf states that he does not believe that in their large flouring-mill, which has been running since 1878, there have been twenty-four hours lost from lack of water. The total amount of power which the present wheels are capable of supplying is 4,000 horse-power; and with the large head used this makes little demand upon the basin, leaving a large supply yet to draw upon. By enlarging the canal this can be immensely increased, and the company claims 70,000 horse-power available from their rights. Anchor-ice getting into the racks has occasionally given trouble for a few hours at a time, but is nothing serious, and by having deep racks may be entirely avoided.

Account of the manufactories.—Starting at the lower end of the basin and going toward the falls, the first thing met is an unfinished race and head-gate, which was intended for a compressed-air company, but was abandoned.

Next is the stone building of the Niagara Falls Wood Paper Company, which at present manufactures wood-pulp only. The water passes through a tube and stand-pipe 5 feet in diameter, and turns a 40-inch Lessner wheel, under 50 feet head. The tail-race is an open cut in the bank. The wheel has a capacity of 250 horse-power, but only 230 are in use.

About 70 feet from the wood-pulp mill is the large flouring-mill of Schoellkopf & Matthews. The total area covered by the building is about 225 feet long, by 90 feet wide, and the capacity is 1,000 barrels of flour per day.

The power is obtained by two American turbines, 52 and 32 inches in diameter, respectively, under 50 feet head. They can work up to 1,200 horse-power, but only 800 to 900 are in use. The water passes to the wheels through a heavy boiler-plate stand-pipe, 9 feet in diameter, with a Y-branch to the wheels. The tail-race is an open cut, about 40 feet long, through the bank. The railroad tracks pass through the center of the building.

From the flouring-mill a wire rope transmits power across the basin to a cooper-shop, supplying barrels, and a manufactory of rustic work on the second floor.

Just above the flouring-mill is a stone wood-pulp mill, controlled by the Cataract Manufacturing Company. The wheel is a 48-inch American turbine, under a head of 84 feet. Great difficulty has been experienced in getting one of sufficient strength. It is probable, that to make wheels satisfactory, under such great pressure, bronze will have to be used in their construction. The wheel-pit was excavated 8 feet in diameter, through the limestone, at a distance of 40 feet from the cliff, and then a 6-foot tunnel was run out to the cliff for a tail-race. The wheel is set in the bottom of the pit; and the 4½-inch steel shaft rises through the center, braced at intervals from the rock sides. The power available is 1,300 horse-power, but only about 700 horse-power is in use. There is a small frame shop adjoining the mill, used in connection with it.

About 60 feet beyond the pulp-mill is Mr. Gaskill's stone flouring-mill, the first building erected at the power. There is a 48-inch turbine, under 23 feet head, supplying 100 horse-power. From 30 to 50 horse-power are also obtained by means of shafting from a wheel set at the water-works, between the mill and the cliff. The tail-race is an open cut.

Between the Gaskill mill and the edge of the cliff are the water-works supplying the villages of Suspension Bridge and Niagara Falls. The Holly system of pumps is used, with a daily capacity of 1,500,000 gallons. The water is usually pumped from the river, but can be taken from the basin if necessary. The water-wheel is a 54-inch American turbine, set over the tail-race of the Gaskill mill, under 26 feet head. It is fed through a boiler-plate pipe 4 feet in diameter. About 40 horse-power is used for the pumps.

Beyond the flouring-mill just described there is a vacant space of 450 feet up to the large pen-stock constructed by the company. About this are located several industries started in 1881–'82, as the power was not completed before that time. At the end of the 30-foot extension of the basin and the 20-foot canal is a bulkhead 40 by 20 feet and 20 feet deep. In addition to the gates at the end of the basin extension there are two at this bulkhead designed by Mr. Rhodes, with very powerful screw-gearing, so as to work readily under the 20-foot head. In front of these is a fine rack, constructed of 2½-inch iron bars ¼ inch thick, and kept about 1 inch apart by distance pieces. Behind the gates is a masonry wall, with three openings for the entrance of boiler-plate tubes 7 feet in diameter, which are intended to supply water to three wheels. Of these only the center one is yet in place, but the other tubes and wheels are to be arranged in precisely the same manner as this. From the bulkhead the tubes pass horizontally for a distance of 60 feet toward the river. 20 feet below the surface of the water. There they reach the wheel-pit, which is 40 by 20 feet and 86 feet deep below the water-surface. Falling 56 feet, the tubes reach a shelf cut in the rock 15 feet above the bottom of the pit, and then drop 11 feet farther to the wheels, which are 6 feet above the bottom. From the wheel-pit a tail-race tunnel 6 by 10 feet in cross-section leads 160 feet to the face of the cliff. The wheel now working is a Risdon turbine, 50 inches in diameter, and under the 80 feet head it gives theoretically 1,076 horse-power, transmitted by a 6-inch steel shaft to the gearing above; it requires 8,370 cubic feet of water per minute, and makes 254 revolutions in that time. It is proposed to put in similar wheels at the other two places, when 3,200 horse-power will be obtained.

The power now obtained is leased by the company, under conditions already mentioned, to five separate industries. At the wheel-pit, and continued over it so as to form a wheel-house, is a fine stone building, the back

of which is a wood-pulp mill owned by Mr. J. F. Quingley. The part over the wheel-pit is owned by the company, and in the basement are the two electrical machines of the Brush Electric Light and Power Company, of Niagara, of which Mr. Benjamin Rhodes is secretary. This company has about 4 miles' length of circuit and forty lights.

Just beyond the mill are the buildings of the Oneida community, which has removed its machinery, etc., from Wallingford, Connecticut. The first building and one extending parallel with the river-bank belong to their extensive plating factory, and the one forming the other side of the hollow square has been erected for a fruit-canning establishment. These, in addition to a machine-shop running with wire rope, are all the industries at present using the large power. The smaller shafts gear upon the main shaft from the wheel by means of conical friction clutches.

It is probable that the two remaining wheels will soon be placed in position, as there is already demand for more power. There is scarcely room in the immediate vicinity of the wheel-pit for using 3,000 horse-power, and it will probably need to be conveyed by shafting or wire rope for a short distance.

This concludes the enumeration of the industries on the basin; and it must be evident that, notwithstanding the large amount of power already in use, scarcely an impression has been made upon the possibilities afforded.

UNIMPROVED POWER OF THE NIAGARA RIVER.

The total theoretical power of the Niagara river has been calculated to be 6,294,000 horse-power, and leaving out that above the rapids and below Lewiston, there remains 5,878,100 theoretical horse-power, which in a certain sense may be considered available, although the idea of harnessing the Niagara is a rather formidable one. The total power which the wheels now in use are capable of supplying is about 5,200 horse-power, and the river offers power sufficient to run 1,100 such manufacturing centers as that at Niagara Falls village, and still leave a surplus of water.

USE OF POWER VERSUS NATURAL SCENERY.

But in discussing the development of the power it will be well not to forget the fact that Niagara is one of the grandest sights of North America, visited by thousands, and worthy of all endeavor to maintain it and its surroundings, so far as possible, with the beauty nature once bestowed. The extensive development of the water-power by either country concerned would be a poor investment, unless with it could be preserved the rush and roar of the waters and the wooded shores. It is possible to make an extensive use of the power without interfering with the beauty of the place, as will presently be seen; and the hydraulic canal and basin do not seriously interfere, because, to a certain extent, removed from the vicinity of the falls; but the two races, with their buildings and stone walls, and also the bazaars and hotels along the shore, certainly are not an improvement on the wild wooded banks which once hemmed the river. Nor can any thing be said in favor of the stores and paper-mill on Bath island, which, although a neat stone building, is not in accord with nature's scenery. The rapid destruction of the natural beauty of the place has long excited apprehension, and an endeavor was made in 1880 to pass a bill in the New York legislature for the establishment of an international park, with the aid of the Canadian authorities. The bill contemplated the purchase of the land bordering the river in the vicinity of the falls, the removal of the buildings, and the restoration of the shores to their natural condition. A report of the state survey, published at the time, sets forth the present condition of the place, and contains views of the river as it would appear with the proposed improvements, but nothing has yet been accomplished.

GOAT ISLAND.

After the preceding remarks, it seems an ungracious task to report the existence of valuable powers, in direct antagonism to the restoration of the scenery. Not to mention the Canadian side, where a fine water-power might be created, there is Goat island, whose surface is on a level with the head of the rapids. The distance of the surface from the water gradually increases, so that at the foot of the island it is about 50 feet above the water.

There is every opportunity for starting one or more canals at the head of the island, and running these down stream 3,000 feet; 50 feet head can be obtained, with extensive mill-sites. By excavating a tail-race tunnel out to the face of the cliff, 200 feet head can be obtained. If a smaller power is required, there are the Three Sister islands, which lie side by side from Goat island toward the Canadian shore.

In each of the three channels a large body of water rushes, which can be utilized, but the largest is in the middle channel, where there is a descent of 15 feet or more, and a stream about 40 feet wide, 3 feet deep, and exceedingly rapid.

THE AMERICAN SHORE.

On the American shore the two races could be greatly enlarged with a sufficient expense, and there is also a fine power available by running a canal through Prospect park from above the falls. For such a canal, about 170 feet head would be available.

Distribution of the power in the form of electricity.—There have been numerous schemes proposed for utilizing the power of the falls in compressing air or generating electricity for light and power at a distance. This is not a physical impossibility, and Sir William Thompson is credited with the statement that he "looked forward to the

falls of Niagara being extensively used for the production of light and mechanical power over a large part of North America", and that a copper wire, half an inch in diameter, would transmit 21,000 horse-power from Niagara to Montreal, Boston, New York, or Philadelphia.

A great disadvantage of this method of transmission appears to be that, as yet, there is an immense loss of efficiency experienced in the transition of the electricity into power. The Brush Electric Light and Power Company, of Niagara, is considering the plan of extending its circuit to Buffalo, and in this case the disadvantage would not be so apparent, as whatever was realized from the use of the electricity for power during daylight would be so much clear gain.

In other schemes that have been devised, results have been anticipated at least commensurate with the fullest utilizing of the whole power of the river.

Leaving now the sites in the immediate vicinity of the village of Niagara Falls, there are yet immense capabilities undeveloped along the American side of the river.

From the condition of the hydraulic basin it is seen that only a very small part of the available power is used, and that every thing is ready for an immediate application of great power.

The cliff that bounds the river at the basin extends all the way down to the end of the gorge at Lewiston, and there is no physical reason why the canal should not be extended and mills built all along the river.

There was a bill passed by the legislature of New York in 1853 for the construction of a ship-canal around the falls to lake Ontario; but, owing to the war, attention was taken from the project, and nothing has been done. In connection with it was a scheme for utilizing the water for power at Lewiston heights. Mills were to be built along the heights, tier above tier, and the water was to be carried to them, the tail-race of one becoming the head-race of the one below, until a great manufacturing city was built up.

INDEX TO THE REPORT ON THE DRAINAGE BASINS OF LAKES HURON AND ERIE,

AND THE

WATER-POWER OF THE NIAGARA RIVER.

REPORT ON THE WATER-POWER

OF THE

MIDDLE ATLANTIC WATER-SHED,

BY

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SPECIAL AGENT.

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REPORT ON THE MIDDLE ATLANTIC WATER-SHED.

PREFATORY LETTER.

BOSTON, MASS., *June* 1, 1882.

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SIR: I have the honor to submit herewith my report on the water-power of the middle Atlantic water-shed of the United States, embracing all the territory drained by streams flowing into the Atlantic ocean from the Hudson to the Chowan, not inclusive.

Following your directions, I have traveled over the region referred to in this report, but necessarily in a hasty manner; and although I visited many of the larger powers in order to form an idea of their availability, lack of time made it necessary to gather the facts regarding numerous important ones by oral inquiry or by correspondence. The only instrument of measurement used was a Locke pocket-level, and in some cases reliable measurements of fall could be obtained, while in others this was impossible.

In preparing the report I have freely used all the material that could be found, and am especially indebted to the reports of the Chief of Engineers, United States army, and to various state documents bearing on the subject. I am also indebted to numerous private individuals, state officers, engineers, railroad officers, and others, for valuable information and advice, and particularly to the officers of the United States Engineer Corps, and their assistants, who have afforded me every facility possible. My obligations are so many that it would be invidious to attempt to name those to whom my thanks are specially due.

In the arrangement of this report I have followed the general method adopted in the case of my previous reports. The drainage areas given were measured in a few cases geometrically, but in most cases with the planimeter, and are believed to be quite accurate. They agree very well with other measurements in all cases where I have had opportunity to compare them.

As regards the estimates of power available, the principles discussed in my former report have served as a guide here, and it is hoped that the estimates given, although they can not pretend to absolute accuracy, will be found to be tolerably close approximations to the truth. I am well aware that these estimates, as well as those given in the report on the New England water-sheds, will to some appear overstrained. It may be thought that they present a semblance of accuracy which they do not possess and which no estimates can possibly possess. In regard to a quantity so variable as the discharge of a stream, it will be asked whether the attempt to present estimates of four different states of flow is not worse than nothing, and whether it is not a needless and deceptive refinement to give more than one estimate. I am conscious of these objections, and my reasons for having given estimates as I have done is simply this: These reports will in all probability be read by persons who are not engineers, and whose ideas in regard to flow and power are not very clear or definite, and general statements would very likely be misunderstood by such persons. The very fact that the flow of a stream is such a variable and fluctuating quantity, and that the amount of power available would depend upon the storage reservoirs which might be constructed, as well as upon the natural flow of the stream, seemed to me to render it especially important to leave no room for misunderstanding as to the state of flow referred to in the estimates offered. If it were said, for instance, that the available power at a certain place varied from 500 to 3,000 horse-power according to the state of the water and the amount of storage utilized, that statement would, it seems to me, be of little value, not only because of its indefiniteness, but because even to those who might understand the meaning of the words, it would give no idea of the way in which the variation between 500 and 3,000 occurred, and how much was due to storage and how much to fluctuations in the natural flow of the stream. It seemed essential, then, in the first place, to give a separate estimate of the maximum power available with storage. In regard to the flow and power without storage reservoirs, the

question arose: Upon what state of flow should the estimate be based? To determine the average flow during the year, or the low-season flow in ordinary or dry years, a series of gaugings is almost a necessity. On the streams in the district now under consideration, however, no such measurements have been made, and the only gaugings at my disposal were some measurements made on a few streams at very low stages of the water, or when the flow was nearly at its minimum. Data regarding this minimum flow being the most numerous, I thought it would be well to tabulate these data (see page 9 of the present report, and pages 9 and 10 of the report on the New England water-shed), and to give estimates of the minimum flow so that the reader could see how they were arrived at, and could disagree with the figures given according as his judgment led him to think the assumed flow per square mile per second was too great or too small. But I am aware of the fact that the minimum flow is not the most important quantity so far as water-power is concerned, because it occurs only at remote periods and lasts only a very short time; and I have felt, therefore, that, in addition to the two estimates referred to, at least one other was desirable. In view of the uncertainty attending all such estimates, and the large error to which they are liable, it would perhaps have been as well to have given an estimate simply of the average low-season flow. But I thought that I could make the subject a little clearer, and show a little more plainly the method of calculation that I had used, by giving the minimum low-season flow and the low-season flow in dry years; for if I had estimated the average low-season flow I should have had to do it by first estimating the two quantities just named, and adding to the latter of them one-fourth to one-third of itself. It seemed to me that in this way not only would the subject be made clearer and the estimates more definite, but that other persons would have better facilities for forming opinions for themselves in the matter, and for disagreeing with me intelligently and on reasonable grounds. In fine, of two evils I chose what seemed to me the lesser, preferring to give to the estimates the appearance of accuracy which they do not possess, rather than leave them in any way indefinite. If once it be understood that they are presented merely as estimates—in some cases almost guesses—that they make no pretensions to absolute accuracy, and that, although some of the estimates given (as the minimum low-season flow and the low-season flow in dry years) differ by only 15 or 20 per cent., either or both of them may be in error by a large fraction of that amount, I think there will be no difficulty and no misunderstanding.

The fact that this report has been written more than a year after the region to which it refers was visited, will serve to explain some of the inaccuracies which it will be found to contain. Not only will changes be found to have occurred in the mean time, but when so long a time elapses circumstances lose their freshness in the mind, and many things would no doubt have been presented in a clearer manner if the report had been written immediately after the region was visited. Some omissions will be found in the report, and lack of completeness in many instances; and while this is due in some cases to the fact that the time was not sufficient to allow of the necessary information being obtained, it is for the most part due to the fact that the attempt to obtain it was unsuccessful. The interest in the subject seems to be less in the district covered by this report, as a whole, than in the more northerly states, and, as a rule, it was more difficult to obtain the desired information. In some cases it was found to be absolutely impossible to obtain by correspondence the statistics desired.

I am, sir, very respectfully, your obedient servant,

GEORGE F. SWAIN,
Special Agent.

THE MIDDLE ATLANTIC WATER-SHED.

Having completed the description of the streams draining the New England water-shed, we proceed to discuss those draining the middle states. We begin, as before, by describing the general character of the region under consideration, after which each stream will be separately considered.

GENERAL CHARACTERISTICS.

1.—Area and form.

The area included in the district under consideration, comprising the region drained by all the streams flowing into the Atlantic between the Hudson and the Chowan, measures in all about 84,300 square miles, and is distributed approximately as follows among the different states:

	Square miles.
Virginia	23, 600
West Virginia	3, 700
Maryland	10, 700
District of Columbia	64
Delaware	2, 120
Pennsylvania	27, 600
New Jersey	7, 400
New York	9, 076
Total	84, 260

This area lies between the parallels of 37° and 43° north latitude, and the meridians of 74° and 80° west longitude, approximately. In shape, it is a strip lying along the Atlantic, with an average width perpendicular to the coast of from 225 to 240 miles, and bounded on the west by an irregular line forming the water-shed between the streams flowing directly into the Atlantic and those flowing west or north into the Mississippi and the Saint Lawrence. This western boundary-line is rather more irregular than in the case of the southern Atlantic water-shed, and topographically the two differ considerably, as will presently be seen. The coast-line, too, is much more irregular and indented than in the case of the southern Atlantic water-shed, and although its general direction is about north-northeast, yet its outline is broken at every step by arms of the sea and extensive bays which penetrate the land to a considerable distance.

2.—Geographical and continental position.

Like the New England water-shed and the southern Atlantic water-shed, the middle Atlantic water-shed lies in the north temperate zone, and the prevailing winds in all are the return trades from the southwest. But as we go toward the north within the district considered, we gradually escape more and more from the influence of these winds, and those from other points of the compass become more common. As in the New England states, the winds from the east and southeast are maritime, and come laden with moisture from the ocean; but here the winds from the southwest, and even those from the south, have passed over large extents of country, and have discharged their load of moisture to a considerable extent, so that they do not partake of the character of sea-winds as much as in the case of the states farther north or south. That the influence of the gulf of Mexico on the region considered is here not of so much importance as regards rain and moisture as in the states farther south may be seen plainly from the Smithsonian charts showing the distribution of rainfall, in which the long finger-like projections extending from the Gulf, and indicating a large rainfall, show, by the fact that they do not extend into the Atlantic states north of North Carolina, that the moisture in those states is derived principally from the Atlantic; and in fact, we see along the coast a large rainfall, which diminishes quite steadily as we proceed inland, being even less in the mountains than on the immediate sea-board; while in the southern states we shall see that the rainfall is greatest in the mountains, because the principal carriers of moisture, the warm southwest winds from the Gulf, blowing parallel with the mountains, of course part with more of their burden in the mountains than in the lower lands. In the region we are now considering the principal carriers of moisture, the winds from the southeast, blow nearly at right angles with the mountains, instead of nearly parallel to them, and as the mountains are not high, and as they approach near to the coast in the northern and middle parts of the region, the rainfall diminishes from the coast inland quite uniformly.

The region now to be considered is bounded on the east by the ocean, on the west by the Alleghany mountains, on the south by the water-shed between the drainage-basins of the James and the Roanoke and Chowan, and on the north by that between the drainage basins of the Hudson and the great lakes, and those of the streams flowing into Delaware, Chesapeake, and Newark bays.

3.—Topography.

In describing the topography of this region it will be convenient, now that we have completed the study of the rather detached New England water-shed, to call attention to the general structure of the Appalachian mountain system, and to the changes in its general features in different parts, and to contrast the region we are about to consider with that already discussed, and with the southern Atlantic water-shed.

The region under consideration, as well as that comprising the southern Atlantic water-shed, may be topographically divided into three quite distinct divisions, which we shall call the eastern, the middle, and the western. The former extends, in the middle Atlantic states, from the coast inland to the head of tide-water and navigation on the rivers, its western boundary being a line, which we may call the *fall-line*, and which marks the geological boundary between the Cretaceous and later deposits which lie between it and the coast, and the older geological formations which lie to the west. It is the most easterly line of outcrop of the older rocks, and marks the last considerable fall on the rivers. In the southern states it passes through Columbus, Georgia; Columbia, South Carolina, Rocky Mount and Weldon, North Carolina, here, however, being some distance above the head of tide-water, and often of navigation; and it may be traced northward quite through the district now under consideration. Passing in Virginia through Petersburg, Richmond, and Fredericksburg, it skirts the Potomac between the latter point and Washington, and, crossing it at a point some 10 miles above the national capital, it continues in a northeasterly direction, remaining nearly parallel to the shore of Chesapeake bay, crossing the Patapsco a little above Baltimore, and the Susquehanna near the state line; then, bending slightly to the east, it crosses the northern part of the state of Delaware, and follows the west bank of the Delaware river up to the great bend at Trenton, where it crosses it. Beyond this point it is not very prominent, but extends almost in a straight line between Trenton and Jersey City, crossing the Raritan near the town of New Brunswick, and the Hudson at its mouth, being there, however, entirely without influence as regards water-power. It will be seen, then, that the eastern division, which in the southern Atlantic states is a broad plain from 100 to 140 miles wide, gradually contracts in width toward the north until it nearly disappears at the mouth of the Hudson and in the northern part of the state of New Jersey; and the same will be seen to be the case with the middle division.

But although the eastern division becomes narrower toward the north, its slope does not vary to the same extent, becoming only slightly greater; and, as a consequence, the fall-line approaches nearer and nearer to navigable waters, until, when we reach the region we are discussing, we find throughout its whole length the fall-line at the head of navigable waters and at the head of tide-water, both navigation and tide being checked by the falls in the rivers at their crossing with that line. The effect of this circumstance, in bringing the water-powers on the fall-line nearer to transportation by sea, is of great importance.

Geologically, the eastern division preserves essentially the same character throughout its whole extent. The soil consists of sand and clay, and the large rivers afford no water-power in that part of their course lying within it, although some of the smaller tributaries, and some of the smaller streams flowing directly into the sea, afford in some cases very good power and belong to the class of sand-hill streams. As already incidentally remarked, the slope of the ground seems to increase somewhat toward the north, and the coasts are not bordered by swamps and lowlands to such an extent as in the southern states; so that, as we shall see in the case of some of the streams in New Jersey, in some cases fine water-powers are obtained, by damming, within a very few miles of the coast.

As regards the area of this division, it includes approximately two-elevenths of the state of Virginia, or about 7,500 square miles; nearly two-thirds of the state of Maryland, or about 7,850 square miles; the entire District of Columbia; about nine-tenths of the state of Delaware, or about 1,900 square miles, and six-tenths of the state of New Jersey, or about 4,600 square miles. Its area in Pennsylvania and New York is too small to be mentioned.

Before describing the middle division, it will be best to consider the principal facts relating to the general structure of the Appalachian mountain chain and the character of the western division. For most of the following notes and quotations I am indebted to Professor Guyot's article on "The Appalachian Mountain System", in the *American Journal of Science and Arts*, 1861.

This great system of mountains, which extends in an undulating line for a distance of 1,300 miles, from the gulf of Saint Lawrence to the state of Alabama, is composed of a number of sensibly parallel chains in the eastern part, and of an extended plateau in the west, which gradually descends to the valleys of the great lakes and of the Ohio and Saint Lawrence rivers. The Atlantic plain, which extends from the base of the mountains to the Atlantic ocean, and includes what we have called the middle and eastern divisions, has a width in New England of about 50 miles, almost vanishes near the mouth of the Hudson, and stretches out to a breadth of over 200 miles in the southern states; and as its slope does not vary much, the elevation of the base of the mountains rapidly increases toward the south and north, starting at the Hudson—being from 300 to 500 feet in New England, almost nothing about the bay of New York, from 100 to 300 feet in Pennsylvania, about 500 in Virginia near the James river, and between 1,000 and 1,200 in the southern part of North Carolina. On the west, the plateau above referred to, and which may be considered the base of the mountains, has a general elevation of about 1,000 feet.

The mountains present three remarkable characteristics: The first is that, as already remarked, they are composed of a series of nearly parallel chains, often very regular and uniform; and that "in the same part of the system the general height of the chains is sensibly equal", their summits showing neither many nor deep notches. Especially in Pennsylvania and New Jersey, the ridges "present the appearance of long and continuous walls, the blue summits of which trace along the horizon a uniform line seldom varied by any peaks or crags. In the extreme northern and southern portions, however, this character is considerably modified. There the system loses very much of its uniformity, and its physical structure becomes far more complicated; the form of simple parallel ridges almost entirely disappears".

The second prominent feature of the system is "its well-marked division into two longitudinal zones of elevation, one turned toward the shores of the Atlantic, in which the form of parallel chains just spoken of predominates, and the other turned toward the interior, which is composed of elevated and continuous plateaus", occasionally wrinkled by minor chains parallel to those on the east.

The third prominent feature is the existence, in the region of corrugations, of a "large central valley which passes through the entire system from north to south, forming, as it were, a negative axis through its entire length". This valley, known as the Great Appalachian Valley, is occupied in the north by lake Champlain and the Hudson river; in Pennsylvania it is known as the Kittatinny or Cumberland valley, and is occupied by the tributaries of the Susquehanna, and in part by the main river; in Virginia it is the great valley occupied by the Shenandoah and some tributaries of the James; and still farther south it is the great valley of East Tennessee, occupied by branches of the Tennessee.

At the northeast and at the center its average breadth is 15 miles; it contracts in breadth toward the south in Virginia, but reaches its greatest dimensions in Tennessee, where it measures from 50 to 60 miles in breadth. The chain, more or less compound, which borders this great valley toward the southeast is the more continuous, and extends without any great interruption from Vermont to Alabama. In Vermont it bears the name of Green mountains, which it retains to the borders of New York; in the latter state it becomes the Highlands; in Pennsylvania, the South mountains; in Virginia, the Blue ridge; in North Carolina and Tennessee, the Iron, Smoky, and Unaka mountains. On the northeast of the Great Valley, between the latter and the borders of the plateau parallel, there extends a middle zone of chains separated by narrow valleys, the more continuous of which is the range which bounds the central valley. This zone has a variable breadth in different parts of the system, and the number of chains which compose it is by no means uniform throughout.

As we proceed from the coast inland, therefore, we cross first the Atlantic plain, then the chain bounding the Great Valley on the east, with parallel ridges and longitudinal valleys, then the Great Valley, and finally the chain beyond, also with parallel ridges and longitudinal valleys, but irregular in structure.

The above are the general features common to the Appalachian system through its entire length, but it may be divided from north to south into three divisions presenting very remarkable differences in structure. The most northerly of these, extending south as far as the deep valleys of the Hudson and the Mohawk, which cut through the system to its base and across its entire breadth, need not here be considered, as it falls without the territory to be specially described. The middle division, which is about 450 miles in length, extends from the valley of the Hudson and Mohawk on the north to the New river, in Virginia, on the south; while the third or most southerly division comprises the remainder of the system. In the middle division the region of parallel chains, "at first very narrow about New York, presents toward the center, in Pennsylvania, its greatest breadth, which again diminishes toward the south. It is composed of a considerable number of chains much curved toward the west, and remarkable for their regularity, their parallelism, their abrupt acclivities, the almost complete uniformity of their summits, and their moderate elevation, both relative and absolute, which varies from 800 and 1,500 to 2,500 feet. The chains, however, increase in elevation toward the south, while they become more numerous and more indented. In the peaks of Otter, in Virginia, they attain to 4,000 feet". The plateau region west of the mountains is quite narrow in the southern part, but very wide in the north. Its high terraces occupy all the state of New York south of the Mohawk, a considerable part of Pennsylvania, and culminate in the plateaus in the neighborhood of lake Erie, where the mean altitude of the plateau reaches 2,000 feet, the valleys preserving a height of 1,500 feet, while the hills reach 2,600 feet.

This table-land forms a remarkable water-shed, from which the waters descend by the Susquehanna into the valley of the Chesapeake and the Atlantic ocean, by the Genesee and Saint Lawrence to the same ocean, and by the Alleghany and Ohio to the gulf of Mexico. The Susquehanna thus starts from lake Erie at the extreme western border of the plateau, and runs across all the Appalachian system and its mountain ranges to its eastern base. More to the southward the eastern escarpment of the plateau divides, as far as the sources of the Potomac, the waters of the Atlantic coast from those of the gulf of Mexico. It is the same escarpment which bears the local name of Allegheny mountain, a name which continues to be applied, south of the waters of the Potomac, to the dividing ridge along the sources of the various branches of the James river, and even to the irregular hills which form a water-shed between the waters of the upper Roanoke and the New river, across the Great Valley, near Christiansburg. Through all this middle region the name of "Blue ridge" is applied to the main eastern chain which separates the Great Valley from the Atlantic slope, and which is cut by all the rivers which flow out of it.

The southern division, from New river to the extremity of the system, is much the most remarkable for the diversity of its physical structure and its general altitude. Even the base upon which the mountains repose is considerably elevated, and in the interior of the mountain region the deepest valleys retain an altitude of from 2,000 to 2,700 feet.

From the dividing line in the neighborhood of Christiansburg and the great bend of New river the orographic and hydrographic relations undergo a considerable modification. The direction of the principal parts of the system is also somewhat changed. The main chain which borders the Great Valley on the east, and which more to the south, under the name of the "Blue ridge", separates it from the Atlantic plain, gradually deviates toward the southwest. A new chain attached on the east, and curving a little more to the south, takes now the name of "Blue ridge". It is this lofty chain, the altitude of which, in its more elevated groups, attains gradually to 5,000 and

5,900 feet, which divides in its turn the waters running to the Atlantic from those of the Mississippi. The line of separation of the eastern and the western waters which, to this point, follows either the central chain of the Alleghanies or the western border of the table-land region, passes now suddenly to the eastern chain, upon the very border of the Atlantic plain. The reason is that the terrace which forms the base of the chains, and the slope of which usually determines the general direction of the water-courses, attains here its greatest elevation and descends gradually toward the northwest. The base of the interior chain which runs alongside the Great Valley is thus depressed to a lower level; and though the chain itself has an absolute elevation greater than that of the Blue ridge, the rivers which descend from the summits of this last flow to the northwest toward the great central valley, which they only reach, in southern Virginia and North Carolina, by first passing across the high chain of the Unaka and Smoky mountains, through gaps of 3,000 or 4,000 feet in depth.

The fact just alluded to, namely, that south of the state of Virginia the water-shed separating the streams flowing into the Atlantic from those flowing into the gulf of Mexico is on the extreme eastern edge of the mountains, is of the greatest importance as affecting the character of the rivers. The Roanoke is the most southerly stream flowing into the Atlantic which has its sources really in the mountains or beyond the first ridge. The James and the Potomac rise in the western part of the system, their tributaries drain the narrow and parallel valleys between the ranges of mountains comprising the system, and they themselves break through these ranges one after another, flowing alternately through narrow gaps and meandering through the intervening valleys, reaching at last the true Atlantic plain; while the Susquehanna and the Delaware take their rise quite beyond the mountains proper, on the plateau which bounds them on the west and northwest, and cut through the entire system to reach the ocean. But the streams south of the Roanoke, which will be described in the following report, have their sources simply on the eastern slope of the mountains, do not drain the parallel valleys lying between the ranges, but are confined altogether to the true Atlantic slope. And it follows from this at once that in the case of the former streams the mountain or western division of their drainage basins is much the most important of the three divisions we have distinguished, while the middle division is of not so much importance; while in the case of the more southerly streams the mountain region is unimportant compared with the middle division. But the change in this respect is of course gradual, and we shall find that in the case of the James and in that of the Potomac the middle division is still as important as any of the three. The effect of the character just alluded to on the flow of the streams is of course very difficult to take into account, but some remarks concerning it will be found farther on.

The preceding quotations from Professor Guyot will serve to give an excellent idea of the character of the western or mountain region of the district to be considered. In regard to its elevation, the mountains rise from a height of 800 or 1,000 feet near New York to 6,000 feet and over in North Carolina, while the Great Valley ascends in a similar way from a height of 50 or 150 feet to 2,000 feet and over, and the Atlantic plain at the base of the mountains from 50 feet or so to 1,200 feet.

The following table of elevations along the Great Valley will show its rise very plainly:

	Feet.
Great Valley at Easton, on the Delaware river, Pennsylvania	159
Great Valley near Leesport, on the Schuylkill river, Pennsylvania	250
Great Valley at Harrisburg, on the Susquehanna river, Pennsylvania	305
Great Valley near Chambersburg, on Conococheague creek, Pennsylvania	600
Great Valley at Shepherdstown, on the Potomac river, West Virginia	280
Great Valley at Port Republic, on the Shenandoah river, Virginia	1,039
Great Valley at Lexington, on the North river, Virginia	894
Great Valley at Salem, on the Staunton river, Virginia	1,070
Great Valley at Newbern, in the valley of the New river	2,065
Great Valley at Mount Airy ridge, highest point near the sources of the Holston river (*a*)	2,595

South of this point the elevation decreases, sinking to 675 feet at Chattanooga.

Of the region draining into the Atlantic, the following are the areas in the different states which may be said to belong to the western or mountainous division:

	Square miles.
Virginia	6,630
West Virginia	3,700
Maryland	1,175
Pennsylvania	27,500
New Jersey	1,300
New York	9,076
Total	49,381

With regard to the middle division, lying between the fall-line and the base of the mountains, little is to be said. Its width increases toward the south from about 15 miles in New Jersey to 120 or more in the southern part of Virginia, and its area may be stated approximately as follows:

	Square miles.
New Jersey	1,550
Pennsylvania	100±
Delaware	80
Maryland	2,425
Virginia	9,525
Total	13,680

a Guyot.

Its elevation above tide at the fall-line is zero, and at the base of the mountains, as we have seen, from 50 to 500 feet. Its slope varies, therefore, from about 3 to 5 feet per mile. Like the middle region of the southern states, it comprises a region varying insensibly from the flat eastern division to the mountainous western one. The streams, in their course through the middle region, offer, as in the case of those farther south, many good sites for power. They are naturally navigable only up to the fall-line, but above that line some of them have been improved by locks, dams, and canals, carrying water communication far inland. It is not true here, however, as it will be found to be in the states farther south, that almost all of the utilized or available water-power is in this section; on the contrary, the great extent of the western district, and the fact that the streams flowing through it are often large, render the facilities for power often better in the latter than in the middle division, and a considerable amount of power is used and available in it.

Another very important topographical feature connected with the region we are considering is the fact that the facilities for storage are excellent in most parts of it. In the more southerly states the streams, not penetrating the mountains, flow through comparatively wide valleys, and are bordered with fertile bottom-lands, sometimes overflowed in freshets, and which could not be flooded permanently without withdrawing from cultivation some of the most valuable of farming-lands. Here, however, the streams penetrate the mountains, and flow through the longitudinal valleys between the parallel ranges often with a small fall; offering therefore facilities for damming and constructing storage reservoirs of tolerably large extent, without the necessity of such expensive dams as would be necessary farther south, and without flooding so much valuable land. And not only are there many sites where artificial reservoirs could be constructed, but there exist in many parts of the region numerous lakes and ponds which contribute in a very efficient manner to render the flow of the streams more uniform, and thus to make the water-power more valuable. The northeastern part of Pennsylvania, along the courses of the Delaware and the Susquehanna, is dotted with lakes; and there are a number in New York and New Jersey. Toward the south they diminish in number, and south of the Susquehanna there is not one in the entire region considered.

Finally, attention may once more be called to the effect of the topography of this region on the facilities for transportation. On account of the many bays which indent the coast, as well as the narrowness of the eastern district, sea-going vessels can often ascend even to the fall-line, and the water-powers are thus quite favorably situated as regards transportation by sea; and the fact that the middle Atlantic water-shed lies principally in the western or mountain district, and belongs to the region of narrow valleys and parallel ranges of hills, has, as will repeatedly be seen, an important effect on transportation by land; for while in the middle states the topography is such that the best and often the only practicable location for railroads is along the streams in the valleys, so that the water-powers are generally easily accessible, in the southern states it is often most economical to locate the roads along the divides, and many of the southern roads are in fact so located (as a glance at the map will show), the water-powers being therefore often many miles from transportation.

4.—Geology, soils, and forests.

So far as the influence of the geology on the water-power is concerned, it will be sufficient to mention briefly a few points. As regards the eastern division, it belongs to the Cretaceous, Tertiary, and later formations, and the soil is clay, sand, and marl. This division does not differ essentially in this respect from the corresponding part of the southern Atlantic states, and it affords a number of sand-hill streams, as we may call them. In the middle and western divisions the deposits are of an earlier age, and belong to the Azoic, Paleozoic, Triassic, and other formations. Some parts of the middle division lie in a belt of red sandstone which is intersected by numerous trap ridges, and this feature has an important bearing on the water-power, for where a stream crosses one of these trap ridges it is very apt to produce a prominent water-power, and some of the largest powers in the region are formed in this way.

One of the most important geological facts which we have to consider, and one in regard to which the middle states stand in contrast with the southern states, is that over the whole northern part of the region is scattered glacial drift, occurring in thick layers in many of the valleys, forming the bed of most of the streams, and covering the rock in some places to a depth of several hundred feet. These drift deposits are found as far south as the southern part of Pennsylvania, but not beyond. South of this limit comes a transition region between the northern glacial region and the southern non-glacial one, in which extensive beds of gravel and sand still occur, and in which the streams flow with quite uniform declivities and are broken by but few precipitous falls. Flowing over such beds of drift or movable material, the natural tendency is for the streams to even out their beds, and to bring down detritus from above to fill up deep places below; and the result is that many of the streams which we shall have to describe offer no falls whatever, but flow entirely in beds of gravel and sand and with uniform slopes; while those of the southern states, as we shall see, offer numerous sites where they fall abruptly a considerable distance over ledges of rock. But we shall also see that even these streams, although the material of their beds is not so movable as sand and gravel or drift would be, are nevertheless gradually attacking their banks and beds, and bringing down from the fields and the mountains detritus and silt, with which they are little by little filling up the falls and

evening out their beds to a uniform slope; and that this result is hastened in some cases by the influence of man. (See description of the Pacolett, Enoree, and Tiger rivers, South Carolina, in the report on the southern Atlantic water-shed.)

The soil of the middle states, except where thick beds of drift occur, is generally not so deep as in the southern states, but it is rather more pervious. It does not shed quite so rapidly the water falling on it, neither does it, when once saturated, part with its water quite so easily as the soil in the southern states.

As regards forests, I have no accurate data regarding the proportion of woodland in the different states beyond the table which will be found in the report on the southern Atlantic water-shed, page 10, to which I must therefore refer. The middle states are doubtless much less thickly wooded than the southern states, and in fact the only Atlantic state which equals them in the proportion of woodland seems to be Maine. It must be remarked, however, that in the southern states a large proportion of the woodland probably occurs in the flat eastern division where there is no water-power, comprising the extensive cypress and pine forests which occur there, and which have no effect in regulating the flow of the streams.

5.—Climate.

The general discussions connected with climate have been so fully considered in the previous report, and tables have been given so much at length, that it will only be necessary here to consider briefly a few points which remain to be examined rather more in detail. We proceed in the same order as in the report alluded to.

a. Coast-line and ocean-currents.—Though the coast-line extends in general parallel to the mountain chains, yet, as we have seen, it approaches them much more nearly on the north than on the south. Reference has also been made to the fact that in the region under consideration the coast is much more indented than in the states farther south. As to the ocean-currents, the coast is bathed by the cold current from the north, which flows along the New England coast between the land and the Gulf stream, and gradually sinks below the latter toward the south. The winds from the sea, therefore, except those from the south and southwest, are apt to be cooler than in the case of the region farther south, and to a greater extent than would be due to their difference of latitude, having swept over cold waters instead of over the warm Gulf stream. Therefore, the winds from the south and southeast are moist and warm, while those from the northeast and east are much cooler. These circumstances, however, are of little importance.

b. Prevailing winds at different seasons.—Though the winds are variable, yet the direction of the prevailing wind is from some point between southwest and northwest, and the general movement of the atmosphere takes place in the same direction. In spring and summer, winds from the southwest, west, and northwest are most frequent; south winds are not so prevalent as in the southern states or in New England, but the southwest and west winds are the most prevalent of all. In winter the winds from the northwest are the most frequent. Winds from the east or north, or from the southeast, are least frequent of all in summer, while in winter north winds occur more frequently. Taken in connection with the shape of the coast, these facts serve to explain the distribution of rainfall over the region, as compared with that over New England and the states farther south, as we shall have occasion to show in brief farther on.

c. Temperature at different seasons.—As will be seen in the case of the southern states, the isothermal lines in the district under consideration extend in a general direction northeast and southwest, being deflected by various influences, principally by the mountains, from their normal course parallel to the equator; so that there are considerable differences in the temperatures for the year and for the seasons, these differences being almost as pronounced from east to west as from north to south. To the tables which have already been given, and to those which will be found on pages 11 and 12 of the report on the southern Atlantic water-shed, nothing need be added here. For more extended data the Smithsonian report (*Contributions to Knowledge*, vol. 21) may be referred to. The principal facts to be gleaned from these tables are the following:

1. The mean annual temperature in the middle states is about 52° F., or about the same as in the western region of the more southern states, and 8° or 10° lower than in the middle parts of those states. This is, however, from 3° to 7° higher than in the New England states.

2. The summer temperature is about 73°, or about 2° higher than in the western parts of the states south, and 4° or 5° lower than in their middle parts; while still 4° to 6° higher than in the New England states.

3. The winter temperature is about 32°, or about 4° or 5° lower than in the western, and 12° or 13° lower than in the middle region of the southern Atlantic states. In New England, however, the winter temperature is from 4° to 11° lower still.

4. The extremes of temperature differ more widely as we proceed north, the range in the middle states being greater than in the southern states, and less than in the New England states; but the difference is mainly in the minimum temperature, for the maximum is not more than 2° or 3° lower in Maine than in Alabama.

5. The same thing is true, in general, for the extremes of mean daily temperature, and for those of mean monthly temperature, although the difference is here, as regards the daily temperature, not so much on the side of the minimum value. The tables given in the reports referred to show that the mean temperature of the hottest

month is about the same in Pennsylvania as in Georgia, while the mean temperature of the coldest month is 10° or 12° lower in the former state. If there is a disadvantage in warm weather as regards water-power, the southern Atlantic states have no reason to complain in this respect, for, contrary to general impression, their summers are not much hotter than those in the middle states.

d. RAINFALL.—For detailed information regarding the rainfall of the region to be considered, the Smithsonian report (Rainfall tables, *Smithsonian Contributions to Knowledge*, No. 353, second edition, 1881) must be referred to, which gives the annual fall, and also its distribution through the year. This region, as regards the character of the distribution of the precipitation, falls essentially under type I, which includes the Atlantic sea-coast from Portland to Washington, and for which the characteristics are given as follows: "Three nearly equal maxima, about the middle of May, August, and December, and one principal minimum, about the beginning of February; the range between the extreme monthly values is small; the August maximum is generally the highest." The following table is the one used in discussing the region, and it will be seen that most of the stations are on the immediate sea-board. It shows that, in the entire region, the monthly rainfall fluctuates between 0.84 of the mean monthly rainfall (in February), and 1.22 of that mean (in August), or that in the month of maximum fall the fall is only 1.45 time what it is in the month of minimum fall:

Month.	Gardiner, Me., 27 years.	Brunswick, Me., 32 years.	Worcester, Mass., 26 years.	Cambridge, Mass., 31 years.	Boston, Mass., 28 years.	New Bedford, Mass., 54 years.	Providence, R. I., 35 years.	West Point, N. Y., 20 years.	Flatbush, N. Y., 36 years.	Fort Hamilton, N. Y., 19 years.	Fort Columbus, N. Y., 24 years.	New York, N. Y., 31 years.	Newark, N. J., 23 years.	Lambertville, N. J., 17 years.	Philadelphia, Pa., 43 years.	Baltimore, Md., 28 years.	Fort McHenry, Md., 23 years.	Washington, D. C., 28 years.	Mean of 18 stations.	Mean of last 11 stations.
January	1.01	0.87	0.99	1.06	1.00	0.97	0.99	0.88	0.94	0.89	0.84	0.90	0.94	0.88	0.89	0.79	0.82	0.91	0.92	0.88
February	0.82	0.74	0.83	0.80	0.94	0.96	0.84	0.81	0.81	0.96	0.77	0.88	0.89	0.86	0.81	0.84	0.77	0.84	0.84	0.84
March	1.02	1.00	0.93	0.96	0.98	1.03	1.01	0.82	0.98	0.91	0.91	0.92	0.93	0.88	0.94	1.12	1.07	0.92	0.96	0.94
April	0.97	0.93	1.00	1.00	1.04	1.02	1.04	1.04	1.02	1.04	0.93	0.99	0.98	0.87	1.00	0.95	1.01	1.13	1.00	1.00
May	1.11	1.22	1.04	1.04	1.10	1.06	1.01	1.25	1.06	1.24	1.31	1.24	1.17	1.18	1.09	1.11	1.07	1.10	1.13	1.17
June	0.97	0.99	0.84	0.86	0.89	0.82	0.91	0.88	1.07	1.08	1.05	1.06	0.86	0.93	1.13	0.97	0.97	1.06	0.96	1.01
July	0.91	0.98	1.02	0.92	1.08	0.87	0.89	1.08	1.01	1.01	0.95	1.01	0.98	1.12	1.08	1.10	0.97	1.25	1.01	1.05
August	1.11	1.18	1.33	1.31	1.10	1.14	1.14	1.30	1.18	1.21	1.33	1.17	1.26	1.35	1.22	1.17	1.24	1.20	1.22	1.24
September	0.82	0.81	0.91	1.06	0.94	0.95	0.89	0.83	0.88	0.89	0.93	0.91	0.93	1.07	0.99	1.01	0.94	0.91	0.92	0.93
October	1.10	1.01	1.07	0.92	0.89	0.98	0.97	1.06	0.99	0.73	0.92	0.88	0.96	0.94	0.91	0.95	0.97	1.01	0.96	0.94
November	1.06	1.25	1.05	1.02	1.03	1.12	1.17	1.03	1.05	0.98	0.95	0.97	1.01	0.88	0.95	0.96	1.00	0.83	1.02	0.96
December	1.10	1.04	0.99	1.07	1.03	1.10	1.14	1.02	1.01	1.05	1.13	1.08	1.09	1.06	1.01	1.05	1.18	0.85	1.06	1.05

For the ratios of fluctuation of the other type curves, for other parts of the country, the report on the southern Atlantic water-shed, page 13, may be referred to. But there is, of course, no abrupt change in the fluctuation from one district to another, the extreme fluctuation in the southern states becoming gradually less as we proceed north; and the last column in the preceding table, which refers to those stations included in our district (to which should properly be added some stations farther south), shows a slightly larger fluctuation than occurs in the entire region covered by the table, namely, 40 per cent. instead of 38 per cent. But if we examine the fluctuation at each station we shall see plainly that it decreases as we go north. It becomes rather different as we recede from the coast, and for more complete information the reports on the separate rivers must be consulted, but the following table will give a general idea regarding stations farther inland:

Month.	Albany, N. Y., 28 years.	Cazenovia, N. Y., 25 years.	Penn Yan, N. Y., 39 years.	Lambertville, N. J., 17 years.	Carlisle, Pa., 22 years.	Lewisburg, Pa., 13 years.	Gettysburg, Pa., 25 years.	Philadelphia, Pa., 43 years.	Frederick, Md., 12 years.	Lynchburg, Va., 7 years.	Mean.
January	0.82	0.79	0.58	0.88	0.74	0.71	0.97	0.89	0.98	0.70	0.81
February	0.79	0.69	0.61	0.86	0.75	0.69	0.80	0.81	0.82	1.22	0.80
March	0.82	0.88	0.70	0.88	0.89	0.86	0.92	0.94	0.75	1.32	0.90
April	0.91	0.94	1.01	0.87	1.00	1.04	1.10	1.00	1.18	1.06	1.00
May	1.16	1.09	1.99	1.18	1.26	1.26	1.19	1.09	1.18	1.03	1.17
June	1.31	1.32	1.42	0.93	1.25	1.26	1.06	1.13	1.58	1.26	1.25
July	1.29	1.25	1.33	1.12	1.27	1.15	1.06	1.08	1.02	0.97	1.15
August	1.00	1.10	1.19	1.35	1.18	1.45	1.06	1.22	0.86	1.21	1.16
September	0.98	1.04	1.16	1.07	1.00	0.97	0.92	0.99	1.16	1.18	1.04
October	1.10	1.13	1.10	0.94	0.85	0.90	0.93	0.91	0.66	0.62	0.93
November	0.95	0.91	0.89	0.88	0.76	0.81	0.93	0.95	0.82	0.87	0.88
December	0.86	0.88	0.71	1.06	1.05	0.90	1.06	1.01	0.99	0.56	0.91

It will be seen that the rainfall is more irregular than on the coast, so that the means vary more from the separate values; but the fluctuation is evidently greater, amounting to 45 per cent. of the mean monthly fall, and at some of the stations it is seen to be even much greater than this. The minimum occurs, as before, in February, but the maximum is several months earlier than before, or in June, and at some stations even in May. But it is noticeable that over the whole district the rainfall is greater in summer than in winter, and never the reverse, as is the case in some of the southern states. A glance at the Smithsonian charts shows that the rainfall is distributed over nearly the entire area about as follows: Spring, 9 to 12 inches; summer, 10 to 14 inches; autumn, 8 to 12 inches; winter, 8 to 10 inches; year, 35 to 48 inches; and it is further noticeable that the distribution does not vary much in different parts of the district. We shall see that in the southern states there is a considerable difference between the sea-board and the western or mountainous parts, the rainfall being greatest in the mountains, and also very differently distributed; for, while on the coast nearly twice as much rain falls in summer as in winter, in the mountains nearly the same quantity falls in each of those seasons. The reason is probably this: The principal carriers of moisture are the winds from the Gulf and the Atlantic ocean, and in summer, winds from the south and southeast being more prevalent than at any other time, the winds which bring rain strike the coast directly from the ocean, or after having passed over a small area of low ground, and are therefore highly charged with moisture, which is condensed along the coast, the amount diminishing as we go inland, until the up-country and the mountains are reached, where, on account of the great height of the latter, almost all of the remaining moisture is condensed and the rainfall is again large; while in winter the winds bringing rain come more from the southwest, and thus reach the coast after having passed over the up-country, and having parted with much of their moisture there and in the mountains, so that in this season the rainfall is small on the coast and again large in the mountains.

In the district we are now considering, however, the mountains are, as we have just seen, lower and more regular than in any other part of the Appalachian system, while the ground rises more rapidly from the coast, leaving only a narrow eastern or tide-water division below the fall-line; so that with the exception of a narrow strip along the coast where the rainfall is greatest, due to the rapid condensation of the moisture in the sea-winds which sometimes blow, and a few isolated spots in the interior where the mountains are higher than usual, or where other influences are at work, the rainfall shows no great variation throughout the area. Toward its southern extremity, of course, the change is gradual from these features to those just described as applying to the southern states; and southern Virginia differs considerably from central Pennsylvania and New York in regard to amount and distribution of rain; but, broadly speaking, the general features above referred to are quite noticeable.

As regards the fluctuation of the annual rainfall in the district under consideration, the table given on page 14 of the report on the southern Atlantic water-shed shows that it offers no peculiarity, and that it is about the same as in the more northern or southern states.

Finally, as to the absolute amount of the rainfall, the data which will be given for each river will be sufficient for the purposes of this report. For more extended information the Smithsonian volume must be consulted.

As a smaller proportion of the winds are oceanic and the mountains are lower than in the states farther south, we should naturally expect the amount of the rainfall to be smaller in the district now to be considered, which is found to be the case; and, in fact, we may say that as regards rainfall there are three principal differences between the middle and the southern Atlantic states: First, the rainfall is greatest in the latter; second, it diminishes from the coast inland quite uniformly in the former, but not in the latter, except for a short distance; third, in the former there is always more rain in summer than in winter, while in the latter this is only true on the coast.

Of course the fact that as we proceed north the precipitation is more and more in the form of snow has an important bearing upon the flow of the streams and upon their water-power; but this effect is so well understood that it may be briefly dismissed here. The northern streams are subject to a winter drought, as the snow often lies on the ground for several months in the winter without melting, and the freshets are usually most severe in the spring when the snows melt; and the ice-jams which sometimes occur, as well as the large bodies of ice which are carried down by the streams, are often very dangerous and destructive to the dams.

FLOW OF STREAMS.

The general facts and circumstances influencing the flow of streams have been discussed with such detail on pages 8 to 10 of the report on the New England streams, that it is only necessary here to endeavor to trace the effects of the climatical and topographical conditions which have just been described, upon the flow of the streams to be described in the sequel, and to try to explain any peculiarities which gaugings have shown to exist; as well as to forecast the probable peculiarities of streams for which we have no measurements, and to draw some comparisons between the streams of the middle Atlantic water-shed and those to the north. The following tables are therefore repeated for convenience of reference and comparison:

Table showing extremes of flow for some American streams.

River.	Place.	Drainage area, square miles.	Mean rainfall, inches. Spring.	Summer.	Autumn.	Winter.	Year.	Remarks on character of drainage basin.	Extremes of flow. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.	Minimum, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	Authority and remarks.
Merrimack	Lowell	4,085	10	11	13	9	43	Lakes and artificial reservoirs. Wooded.	81,000	1,275	.64	0.31		
Merrimack	Lawrence	4,599	10	11	13	9	43	......do	96,000±	1,400	70	0.31		
Concord	Lowell	361	11	11	12	10	44	Stream sluggish and swampy. Few woods. Hilly and rolling. Some reservoirs.	4,449	59.84	74	0.17		C. Herschel.
Sudbury	Framingham	78	11	11	12	10	44	Hilly and swampy. One-sixth to one-eighth wooded.	3,228	2.80	1,153	0.036		A. Fteley.
Charles	Newton Upper Falls.	215	11	11	12	10	44	Hilly and rolling		44*		0.20		J. P. Kirkwood.
Hale's Brook, Mass.	Mouth	24	11	11	12	10	44			3.24		0.135		J. P. Frizell.
Connecticut	Hartford	10,234	10	12	12	10	44	Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.	207,443	5,219	40	*a* 0.51		T. G. Ellis.
Connecticut	Dartmouth	3,287	10	12	12	10	44	......do		1,006		0.306		C. Herschel.
Housatonic		790	12	12	12	10	46			130		0.165		H. Loomis, Rept. N. Y. Com. Pub. Wks., 1879.
Croton		338.82	12	13	13	10	48		25,367	50.80	500	0.15		J. J. R. Croes and G. W. Howell.
Croton, West branch.		20.37	12	13	13	10	48	Very broken and undulating. Hilly, steep, and rocky. Largely wooded. Little cultivated.	1,100	0.407	2,722	0.02		J. J. R. Croes.
Passaic	Paterson	813	12	14	12	10	48	Some lakes and swamps. Hilly.		178		0.22		J. J. R. Croes and G. W. Howell.
Do	Belleville	962	12	14	12	10	48	......do	19,944	225.60	88	0.023		J. J. R. Croes and G. W. Howell.
Delaware	Lambertville	6,500±	11	13	11	9	44	Hilly and rolling. Many lakes. Well wooded.	350,000	2,000	175	0.30		Ashbel Welch.
Schuylkill	Philadelphia	1,800	12	14	10	9	45	Hilly and rolling. No lakes. Some reservoirs.		307 to 378		0.17 to 0.21		E. F. Smith and H. P. M. Birkinbine.
Hackensack		84	12	14	12	10	48	Flat. No lakes or reservoirs, except mill-ponds.		27		0.33(?)		C. D. Ward.
Ohio	Pittsburgh	19,900	10	12	9	10	41	Hilly and mountainous. No lakes. Wooded.		2,271		0.114		J. H. Harlow.
Potomac	Cumberland	920	10	12	9	8	39	Narrow valleys. Steep slopes. Wooded. No lakes.	17,900	25	716	0.022		W. R. Hutton and Patterson.
Do	Dam No. 5	4,640±	11	12	9	8	40	......do	92,772	363	255	0.0783		Quoted by W. R. Hutton.
Do	Great Falls	11,476	12	13	9	8	42	Country more open. No lakes.	175,000	1,063	165	0.093		W. R. Hutton.
Rock Creek	Hoyle's mill	64.40	11	12	11	8	42			7.50		0.114	0.458	Quoted by W. R. Hutton.
Kanawha	Charleston pool	8,900	12	13	9	10	44	Mountainous. Steep. No lakes. Wooded.	120,000	1,100	110	0.123		Gill, Scott, and Hutton.
Greenbrier	Mouth of Howard's creek.	870	11	12	8	9	40	......do		97		0.12		McNeill.
Shenandoah	Near Port Republic.	770	12	13	8	8	41	Hilly. Limestone. No lakes. Many springs.		128		0.167		James Herron.
James	Richmond	6,800	12	12	9	10	43	Mountainous in upper part. No lakes. Wooded.		1,300		0.191		H. D. Whitcomb and W. E. Cutshaw.
Neuse	Near Raleigh	1,000	12	13	10	10	45	Open. Clay and loam. No lakes. Few extensive woods.					0.193	W. C. Kerr. "Low water".

a Since the date of Ellis' measurements the flow of the Connecticut has been as low as between 0.25 and 0.30 cubic foot per second per square mile, according to good authority.

Table showing monthly distribution of flow.

MONTHLY FLOW IN DRY YEARS.

Rivers.	Drainage area, square miles.	FLOW IN INCHES ON WATER-SHED.													RATIO OF MONTHLY TO MEAN FLOW.											
		Driest month.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.	Total for the year.	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.
Croton	339	0. 20	0. 35	0. 53	0. 63	0. 87	0. 94	1. 52	1. 63	1. 80	1. 90	2. 08	2. 27	14. 72	0. 16	0. 29	0. 43	0. 51	0. 71	0. 77	1. 24	1. 33	1. 47	1. 55	1. 70	1. 85
Concord	361	0. 25	0. 32	0. 36	0. 43	0. 54	0. 68	0. 85	1. 07	1. 36	1. 70	2. 15	3. 62	13. 33	0. 22	0. 29	0. 32	0. 39	0. 49	0. 61	0. 76	0. 96	1. 23	1. 53	1. 94	3. 26
Merrimack (*a*)	4, 599	0. 68	0. 70	0. 77	0. 85	1. 00	1. 13	1. 30	1. 53	1. 98	2. 55	3. 22	5. 42	21. 13	0. 38	0. 40	0. 44	0. 48	0. 57	0. 64	0. 74	0. 87	1. 12	1. 45	1. 83	3. 08
Connecticut	10, 234	0. 65	0. 68	0. 71	0. 74	0. 88	0. 90	1. 28	1. 51	1. 80	2. 02	3. 28	4. 71	19. 16	0. 41	0. 43	0. 45	0. 46	0. 55	0. 56	0. 80	0. 95	1. 13	1. 26	2. 05	2. 95
Schuylkill (*b*)	1, 800	0. 27	0. 30	0. 38	0. 40	0. 53	0. 62	0. 68	0. 79	0. 88	0. 98	1. 08	1. 59	8. 50	0. 38	0. 42	0. 54	0. 57	0. 75	0. 88	0. 96	1. 12	1. 24	1. 38	1. 52	2. 24
MONTHLY AVERAGE FLOW FOR A SERIES OF YEARS.																										
Croton	339	0. 56	0. 95	1. 12	1. 21	1. 43	1. 82	2. 30	2. 57	2. 77	3. 02	3. 60	4. 00	25. 35	0. 26	0. 45	0. 53	0. 57	0. 68	0. 86	1. 09	1. 21	1. 31	1. 43	1. 70	1. 90
Concord	361	0. 39	0. 46	0. 51	0. 61	0. 76	0. 96	1. 25	1. 52	1. 92	2. 38	3. 00	4. 86	18. 62	0. 25	0. 30	0. 33	0. 39	0. 49	0. 62	0. 81	0. 98	1. 24	1. 53	1. 93	3. 13
Merrimack (*a*)	4, 599	0. 77	0. 88	1. 06	1. 26	1. 52	1. 80	2. 12	2. 49	3. 03	3. 73	4. 63	6. 56	29. 85	0. 31	0. 36	0. 43	0. 51	0. 61	0. 72	0. 85	1. 00	1. 22	1. 50	1. 86	2. 63
Connecticut	10, 234	0. 75	0. 85	0. 91	1. 10	1. 34	1. 58	2. 00	2. 36	2. 81	3. 27	4. 52	6. 26	27. 75	0. 33	0. 37	0. 39	0. 47	0. 58	0. 68	0. 87	1. 02	1. 21	1. 41	1. 96	2. 71
MONTHLY FLOW IN DRY YEARS OF STREAMS OF SMALL DRAINAGE AREA.																										
Cochituate	19. 00	0. 08	0. 41	0. 46	0. 47	0. 70	0. 88	0. 97	1. 03	1. 11	1. 31	1. 47	2. 26	11. 15	0. 09	0. 44	0. 50	0. 51	0. 75	0. 95	1. 03	1. 11	1. 20	1. 41	1. 58	2. 43
Croton, West branch	20. 37	0. 10	0. 17	0. 46	0. 53	0. 67	0. 84	0. 98	1. 02	2. 31	3. 37	3. 41	5. 40	19. 26	0. 06	0. 10	0. 28	0. 33	0. 42	0. 52	0. 61	0. 64	1. 44	2. 10	2. 13	3. 37
Sudbury	78. 00	0. 11	0. 16	0. 25	0. 39	0. 57	0. 79	1. 06	1. 40	1. 79	2. 21	2. 77	5. 09	16. 59	0. 08	0. 11	0. 18	0. 28	0. 41	0. 57	0. 77	1. 01	1. 29	1. 60	2. 01	3. 69
Passaic head-waters	50–100	0. 11	0. 15	0. 21	0. 27	0. 49	0. 67	0. 90	1. 22	1. 77	1. 87	2. 13	3. 65	13. 44	0. 10	0. 13	0. 19	0. 24	0. 44	0. 60	0. 80	1. 09	1. 58	1. 67	1. 90	3. 26

a Regarding the figures given for the Merrimack river, it should be noted that as they are based on gaugings for only six months in each of a series of years, they can not be considered anything but approximations, and are simply given for want of some hing better. The figures for the last six months are especially liable to large errors.

b Charles G. Darrach, in *Engineering News*, April 3, 1880, p. 122.

The first point to be considered is the rainfall; and the fact that in the middle states the rainfall is greatest in summer has an effect which is perhaps very large, and which may go far toward explaining the large summer flow of some streams in those states. The table shows that although the minimum flow of the Schuylkill river is not much greater than that of the James, yet its average flow in the driest month is very large indeed; and when we bear in mind that the drainage area is not large, that it includes no lakes and only a few storage reservoirs of the canal company, that the forests are not exceedingly extensive, and that a good deal of the land is under cultivation, we may be disposed to attribute the principal part of this effect to the fact, which the table shows, that the rainfall on the basin in summer and fall is very large—larger, in fact, than in the case of any stream south. Still, how far this may be due to the artificial reservoirs or to errors in estimating the flow can not be stated. If we compare the streams in the middle Atlantic water-shed with those in the southern, we are, I think, entitled to conclude that, as regards this factor in the problem, the flow of the former is the more constant, except in the case of some streams in Virginia where the rainfall is distributed unfavorably. As to streams in New England, the large summer rainfall, and the numerous reservoirs, render their flow undoubtedly more uniform than that of any of the streams now under consideration.

Again, the fact that toward the north the winters are colder and the fall of snow greater has the effect of tending to make the winter flow of the streams less than the summer flow. The streams being really lower in summer than in winter on the Atlantic coast, a cold winter with much snow may therefore in some cases be regarded as favorable and as tending to equalize the flow. Compared with the streams of the southern Atlantic slope, those in the middle states have therefore the advantage in this respect, and we may say that, as regards this factor of the problem, their flow is more constant. It is unnecessary to refer further to the spring freshets in the north due to the melting of the snows, except to remark that if the winter snows lie long on the ground and are carried off suddenly in the spring they may do little toward increasing the summer flow of the streams, so that their effect in regulating flow would simply consist in diminishing the average winter flow and causing severer freshets, and thus that effect would be really unfavorable. The diversity of the conditions of the problem is so great, however, that general conclusions must be made cautiously.

The next point which it is necessary to consider is the effect on the flow which is exercised by the topographical peculiarities of the region under discussion; the most striking topographical feature being the fact that the streams now to be considered rise in the mountains, or toward their western extremity, and flow across them, while the more southern streams rise on their extreme eastern side. Of course the effect of this physical conformation can not be definitely stated or brought to mathematical form; but one result seems to be derivable from it, namely, that the extreme variability in flow of some of the streams which rise farthest in the mountains, draining with their tributaries the numerous narrow and parallel longitudinal valleys between the ranges, is in great part due to this

topography. The remarkably low flow of the James and Potomac rivers in dry weather does not find a parallel in the table, except for streams of small drainage area. A glance at the table shows that the rainfall on the drainage basins of these streams is not distributed in a way favorable for a constant flow through the year, and it may be that this fact plays the principal part in causing the low flow observed; but until we possess more accurate data, and measurements sufficiently extended, to enable us to gain some numerical idea of the effect of the various circumstances which affect flow—a desideratum which can with difficulty be supplied—we are forced to estimate these effects according to our judgment; and to my mind it seems as if the topography would have a much greater influence than the distribution of the rainfall. The result thus reached is of value in showing us how to estimate the flow of other streams; and in judging of the power of streams draining a number of narrow valleys we have not lost sight of it.

The next circumstance which is to be borne in mind is that the soil in the region considered is, as a whole, rather more porous, though not deeper, than in the states farther south. The mountains are oftener rocky and bare and the depth of soil perhaps less on the average, but, the porosity being greater, the flow of the streams will not on that account be less uniform.

The third fact, and perhaps the most important of all, is that many of the streams in the middle states have numerous lakes tributary to them, and, further, that the form of the valleys is generally favorable for the construction of storage reservoirs. The power which will be found estimated in the tables as the "maximum with storage" may, in most cases of small drainage areas, be considered really available, while in the case of the southern streams we shall see that, though possible to utilize it, its complete utilization is in most cases impracticable or unadvisable. This fact is important in judging of the value of sites.

In regard to the forests, their action will be referred to at length in a subsequent report. No data are at hand sufficient to enable us to estimate the amount of woodland in the different states, and we are therefore unable to bring this factor much into consideration; but from the facts stated on page 20 of the report on the southern Atlantic water-shed it is clear that with the rainfall always greater in summer than in winter, as it is over our present district, the influence of the woods is most beneficial. Bearing these points in mind, I have estimated the power and flow at numerous points, following the same method which was explained on pages 8 to 10 of the report on the eastern New England water-shed. Although it is not necessary to explain the method of calculation in this place, it may be well to repeat the definitions given before of the various quantities which have been estimated, as follows:

1. ABSOLUTE MINIMUM can be depended upon always and with no storage at all. Large waste all the time, except for a few days at a time, at intervals of several years.

2. MINIMUM LOW-SEASON FLOW, with no storage, can be depended upon at all times, except for a short time in some dry seasons—perhaps for a few days in the dry season of each year. With small storage, can be depended upon all the time.

3. MEAN FLOW IN VERY DRY YEARS.—*Maximum amount permanently available with storage.*—Storage capacity, perhaps 3 or 4 inches on the water-shed. With larger storage a greater amount could perhaps be utilized for several years in succession, but not permanently. Generally impracticable except in the case of very small drainage areas.

4. LOW-SEASON FLOW IN ORDINARY DRY YEARS, without storage, can be depended upon generally, except in the low season of dry years, when the supply will be deficient for perhaps several weeks; in very dry years, when the supply will be deficient for a longer time; and in ordinary years, when the supply may be deficient for a few days at a time. Can be rendered permanently available by storage. The *low-season flow of ordinary years* can be depended upon less than the above, but generally for nine months of every year.

In regard to the maximum with storage, the powers given for large drainage basins, although perhaps in some cases really available, could be made so only at great cost. Small basins are more favorable in this respect, and the amount of water available is also proportionally greater, because there is considerable loss by evaporation in the case of large basins while the water is flowing from the distant reservoirs to the points where it is to be used.

TIDAL WATER-POWER.

There is no tidal water-power in the middle Atlantic water-shed. The country along the coast is in most places too flat, and not suitable for building, the range of the tides is small, and there is no advantage to be obtained by using the power of the tides, as it is sometimes used in New England.

TOTAL AVAILABLE POWER.

I have made no attempt to estimate the total available power of the streams in the middle states. Such estimates are liable to mislead, and, although they will be given in the case of some of the southern streams, I have thought it best to omit them here. But the remark may again be made, that the elevation of the Atlantic plain at the foot of the mountains becomes smaller as we proceed north, being 1,200 feet in North Carolina, 500 feet in Virginia, and from 100 to 300 feet in Pennsylvania; so that, as regards those streams which do not rise beyond the first ridge of the mountains, their total theoretical power will be much less in the region we are considering

than that of streams of equal size farther south; but from the fact that in our present region the larger streams do not rise on the eastern slope of the mountains, but near their western edge, or even on the elevated plateau beyond, as in the case of the Susquehanna and Delaware, this conclusion can not be drawn generally. The sources of the Susquehanna, for instance, lie at an elevation of about 1,200 feet, so that its total fall to tide-water is greater than that of any southern stream, if the small upper sources be left out of account. Any sweeping statements regarding total power available must therefore be taken with considerable allowance, and are likely to give a false impression.

6.—General results.

Before proceeding to describe each river in detail, a few of the general results of the characteristics which have just been discussed may be briefly mentioned. From the topography of the region it is clear that the water-powers are, as in New England, more evenly distributed over its whole extent than in the southern states, where will be found large areas without any powers whatever. The eastern division of the Atlantic slope being very narrow in the north, and the middle region small, the greater part of the water-power, especially in the northern part of the region, is in the western or mountainous division; and while the gradual fall of the streams makes concentrated falls and cataracts perhaps on the whole less numerous than in New England or in the south, yet the region now to be considered has an advantage over the southern states in the matter of storage, and especially in the fact that some of its streams are fed by numerous lakes.

In those parts of the region where the streams drain numerous parallel valleys of the mountains, often covered with soil to a smaller depth than in the south, the very variable flow of the streams, and the liability to sudden and severe freshets, is a disadvantage; and, in the cases referred to, it is not compensated by the presence of lakes or by particularly good facilities for storage. The rain falling on these narrow valleys is rapidly gathered into the water-courses—especially if the mountains are not deeply covered with soil—swelling the volume to a great extent, and rendering the flow much more variable than it otherwise would be. The James and Potomac rivers are especially subject to this influence.

Regarding the forests, their preservation is a matter of great importance, for their usefulness as regulators of flow is very great, especially as the rainfall is greater in summer than in winter. In some parts of the region the forests are, unfortunately, being rapidly destroyed by lumbermen, but no data are at hand regarding the actual extent of woods or the rate of destruction. The operations of the lumbermen have in some cases a very important influence on the water-power of the streams—especially the smaller ones—down which the logs are floated, as we shall have occasion to see when speaking of the west branch of the Susquehanna river, on account of the intermittent flow caused by suddenly opening the artificial reservoirs which are constructed for the purpose of floating down the lumber on the swell or wave which results, according to the same method which was formerly used on some of the rivers in France, as well as on the Thames and Severn in England (and still in use on the former stream), for purposes of navigation (*navigation par éclusées*). The wholesale destruction of our forests now being practiced must before long lead to unpleasant results, similar in kind (we hope not in degree) to those which have taken place in some of the streams of the Alps; and to the many words of warning which have been written from economical and agricultural points of view, must be added another—the undoubted injurious effect which such destruction will have on the water-power of the streams whose drainage basins are so being robbed of their natural protection.

In regard to the temperature of the region under consideration, the facts that the yearly mean is lower, and that the winter mean is considerably lower, than in the states farther south, are the principal ones which have a bearing on water-power. Although the streams in Virginia are seldom frozen over, and the mills suffer little trouble or interruption from ice, yet as we proceed north this source of trouble increases, and in the northern part of the district, and in New England, it sometimes assumes considerable proportions. Then, again, the freshets in spring, at the breaking up of the rivers and the melting of the snows, though perhaps not more severe than on some southern streams, are yet accompanied by such great masses of floating ice that their destructive effect on the dams is frequently greater, so that those structures have to be built often in a very substantial manner. The evil effects of ice-jams, which sometimes occur and cause the overflowing of considerable areas, are too well known to need more than mention here, having already been referred to in the previous report.

Again, regarding the objection sometimes urged respecting temperature against the advantages for manufacturing in the south, this point will be discussed with sufficient detail on page 23 of the next report, so that it is only necessary to state here that in the district now under consideration the temperature in the hottest month, or even the average in summer, is very little lower than in the southern Atlantic states and but little higher than in New England; and that it would seem that this matter of temperature is on the whole a factor of very little consequence in the question, except, of course, in so far as it goes to determine evaporation and other meteorological phenomena.

The facts regarding rainfall, which have been alluded to, have already been considered in their effects on water-power, when speaking of the flow of the streams. Their importance is great, and when we bear in mind the difference in distribution of rain, in the occurrence and number of lakes, and in the topography of the regions drained by the different streams, we shall have no difficulty, I think, in explaining the facts given in the table of flow of streams, and in arriving at tolerably close estimates of flow in cases where gaugings are not at hand.

Finally, the advantage as regards transportation must once more be mentioned which follows from the fact that the streams in the region now to be considered are navigable up to the fall line, thus placing some of the largest powers in the whole region in a very favorable position in this respect. In Maine the water-power region has been seen to approach still nearer to the sea-coast, but in the southern states we shall see that the powers are often separated from tidal waters by over a hundred miles of a tortuous stream, and that although this distance can be made navigable for river-boats, sea-going vessels can not reach the powers as they can those farther north.

After these few general remarks, I proceed to give as detailed a description of each river as the material which I have been able to collect will allow. In order to compare the power available at different places to be described with that at well-known places in the New England and other states, the following information may be found interesting. It is taken from the statistics given in this volume, principally from the reports on the New England states. At Paterson, New Jersey, the Passaic river furnishes, when at its minimum, about 1,200 gross horse-power, night and day. At Lowell, Massachusetts, the Merrimack has a fall of 35 feet, and yields at a minimum about 12,000 gross horse-power during the usual working hours. At Cohoes, New York, the Mohawk falls 105 feet, and would yield at least 18,000 gross horse-power during working hours. At Manchester, New Hampshire, the Merrimack falls 52 feet, and gives a minimum of about 12,000 gross horse-power during working hours. At Lawrence, Massachusetts, the same stream falls 28 feet, yielding a minimum of about 11,000 gross horse-power during working hours. At Holyoke, Massachusetts, the Connecticut has a fall of 56 feet, and a minimum of about 14,000 gross horse-power during working hours. At Lewiston, Maine, the fall in the Androscoggin is 50 feet, and the minimum power, during usual working hours, is about 12,000 gross horse-power. At Birmingham, Connecticut, the Housatonic falls 22 feet, furnishing a minimum of about 1,400 gross horse-power during usual working hours. The improved fall of the Connecticut river at Turner's Falls is 41 feet, furnishing a minimum, during working hours, of about 14,000 gross horse-power.

I.—THE JAMES RIVER AND TRIBUTARIES.

THE JAMES RIVER.

The James river is formed in the extreme northern part of Botetourt county, Virginia, by the union of Jackson's river with Cowpasture river, both of which take their rise in the mountains of Highland county, and flow in a direction rather west of south, traversing longitudinal and comparatively narrow valleys between the nearly parallel ranges of the Alleghenies. From their junction the James pursues a general course nearly east, flowing first through Botetourt and Rockbridge counties, and for the remainder of its course forming the boundary line between the counties of Bedford, Campbell, Appomattox, Buckingham, Cumberland, Powhatan, Chesterfield, Prince George, Surry, Isle of Wight, and Nansemond, on its right, and Amherst, Nelson, Albemarle, Fluvanna, Goochland, Henrico, Charles City, James City, and Warwick, on its left, emptying into Chesapeake bay through Hampton roads, not over 20 miles from the Atlantic ocean. The stream, with all its tributaries, lies wholly within the state of Virginia. Its total length, measured along its course, is about 335 miles, while in a straight line it is only about 200 miles. Its total drainage area is about 9,700 square miles, and its principal tributaries are the following streams, mentioned in their order as the river is ascended:

Drainage areas.—Tributaries of the James river.

	Square miles.
From the north:	
Chickahominy river	410
Rivanna river	668
Hardware river	245
Rockfish river	240
Tye river	425
North river	784
From the south:	
Appomattox river	1,565
Willis river	247
Slate river	223
Catawba creek	112
Craig's creek	357

The head-waters—Jackson's and Cowpasture rivers—drain, respectively, areas of 988 and 580 square miles.

The basin of the James is varied in character, being mountainous in the upper part, and very low, flat, and often swampy in the lower part. Jackson's and Cowpasture rivers wind through narrow and picturesque valleys, over beds generally of sand and gravel, with rock ledges in places, and are bordered with fertile bottom-lands. Their fall is on the whole not great, although in places there are local falls of some consequence. The James, cutting as it does through the ridges of the mountains to reach the Atlantic plain, flows alternately across the valleys, with a gentle current, a bed of sand and gravel, and fertile level lands along its banks, and through breaks in the ridges, with steep, rocky, and sometimes precipitous banks, the fall being in these localities often

considerable, and the bed solid rock, sometimes overlaid to a small depth with movable material. The most noticeable places of this kind are near Buchanan, near the mouth of North river, and at one or two other places above Lynchburg. Below the latter place the country is more open, but the stream has considerable fall all along its course through the middle or hill country, as far down as Richmond, where it crosses the fall-line, and below which the basin is flat and low. The accompanying map shows the position and form of the basin. It extends farther into the mountains than the basin of any Atlantic stream farther south, excepting perhaps the Roanoke, so that all three divisions of the Atlantic slope—the western, middle, and eastern—are well represented. The latter, however, extends only up to the head of tide-water, where the Virginia streams cross the fall-line. Geologically, the eastern division is alluvial, just as in the states farther south, and the middle division is for the most part of the Eozoic formation, with some patches of sandstone. The western division is more varied in character than farther south, and is divided by the Valley region into two quite distinct parts—the Blue ridge on the east and the true mountain region on the west—and it is through the Blue ridge that the river breaks near the mouth of North river, passing from the Valley to the Piedmont region or middle division.

The products of the James River basin are chiefly cereals, fruit, vegetables, etc. A large part of the area is covered with pine forests, but no data are at hand for determining the proportion of the basin so covered. In the entire absence of lakes and artificial reservoirs, excepting the canal ponds on the James, the woods are doubly important.

The James is remarkable as being navigable for sea-going vessels drawing 16 feet up to the head of tide-water, or to the fall-line at Richmond, a distance from the mouth of the river of 111 miles in a channel line and 130 miles from the ocean. The falls at Richmond form an insurmountable obstacle to the further navigation of the river, but by means of the James River and Kanawha canal, which was built along the stream many years ago, transportation has until recently been afforded as far as Buchanan, 196½ miles above Richmond, and it was expected to extend the canal across the Alleghenies to join the Ohio; but having recently been purchased by the Richmond and Allegheny Railroad Company, which is constructing the road directly along the tow-path, it is now entirely abandoned as a means of communication, and is superseded by the railroad. There are no very large towns on the river except Richmond, and Lynchburg 146 miles above. Buchanan, though a small place, has been of some importance as the western terminus of the canal. The accompanying map shows the railroad traversing the basin of the James, rendering the stream accessible for its entire length, while the canal, having been abandoned for navigation, can be made to afford a very large amount of water-power, as will be seen hereafter, and with the very best facilities for transportation.

The following table will show that the fall of the James river is considerable; but with the exception of the falls at Richmond, I obtained no information of any particularly large falls in short distances:

Table of declivity of the James river.

Locality.	Distance from Richmond.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Richmond—foot of falls	0	0			
			3	84	28
Grant's dam	3	84			
			8	40	5
Bosher's dam	11	124			
			18	19	1.06
Maiden's Adventure dam	29	143			
			80	232	2.9
Tye River dam	109±	375±			
			26½	88	3.32
Joshua Falls dam	135½	463			
			13	50	3.85
Lynchburg Water Works dam	148½	513			
			3½	27	7.7
Judith's dam	152	540			
			5	18	3.6
Bald Eagle dam	157	558			
			3	14	4.66
Pedlar dam	160	572			
			2½	16	6.4
Coleman's Falls dam	162½	588			
			4	18	4.5
Big Island dam	166½	606			
			4	43	10.75
Cushaw dam	170½	649			
			5	57	11.4
Blue Ridge dam	175½	706			
			3	14	4.66
Quarry Falls dam	178½	720			
			7	39	5.57
Varney's Falls dam	185½	759			
			4	27	6.75
Indian Rock dam	189½	786			
			4½	26	5.77
Wasp Rock dam	194	812			
			4	0	....
Buchanan	198	812			
			27	202	7.5
Junction of Jackson's and Cowpasture rivers	225	1,014			

The preceding table gives the elevation of each dam on the river; but as the dams pond the water for some distance in many cases, it does not give an exact idea of the natural fall of the stream. It will be seen that the fall between the head of the falls and Lynchburg, about 145 miles, is at the rate of about 3 feet per mile; while from Lynchburg to the junction of the two head-waters, about 77 miles, it is at the rate of 6.5 feet per mile.

The rainfall on the valley averages from 42 to 45 inches. Near the coast it is 50, and between the coast and Richmond it varies from 50 to 44, while above Richmond it diminishes, reaching 38 in the mountains. The table of utilized and available power, on page 23, will give details regarding the amount and distribution above various points.

The flow of the river is subject to very great fluctuations and the freshets are very heavy. Those of 1870 and 1877 were remarkable for their violence, and did considerable damage along the river, and that of 1870 is said to have been the heaviest freshet within a century, up to that time. In 1877 the river is said to have risen 28.9 feet below the falls at Richmond, and 26 feet at the pump-house a mile or so above. The cause of this variability in flow is probably to be sought in the absence of lakes, the narrowness of the valleys, and the steepness of the hill-sides, and in the small rainfall in autumn, which tends to reduce the low-season flow to a small amount (see table on page 9). The stream is not subject to heavy ice-freshets, and ice-gorges seldom occur. In 1879, however, a heavy gorge occurred just below Richmond which was the cause of some damage, the water having been backed up to a considerable height. Those mills at Richmond and at Manchester which do not use water from the canal are generally obliged to stop at intervals in times of high water. I have only one record of a gauging of the stream, viz., that given in the table just referred to, and it has served as a guide in many estimates. No measurements of the maximum flow have come to my knowledge. The bottom-lands along the stream seem to be on the whole less extensive and less subject to overflow than on the streams farther south. Notwithstanding the severe freshets, however, no trouble is experienced in keeping the canal dams in good order, on account of the excellent foundation for such structures which is to be found all along the river—generally solid rock covered with a thin layer of gravel and sand. The facilities for the construction of storage reservoirs in the upper valleys, to restrain the floods and to render the flow more uniform, are on the whole not very good, on account of the narrowness of the valleys and their rapid fall, although sites could doubtless be found. The necessity for such reservoirs has, however, not yet been felt, and no accurate examinations have been made on this point, so far as I could learn.

The fine opportunity which is at present afforded of utilizing a large amount of power by means of the now abandoned canal can not be too strongly emphasized. It has fine collateral advantages—climate, means of transportation, building-materials, etc.—but in my limited work it was, of course, not possible to make a detailed examination of the canal to determine just what sites would be most favorable. The total fall of the river between Richmond and Buchanan, amounting to 812 feet, having been overcome by a series of locks, dams, and canals, there is every reason to believe that a large proportion of the total theoretical power of the stream between those points may be considered available if the canal can be made of sufficient capacity to carry the low-water discharge of the river. With such a large amount of power available it is evidently unnecessary to attempt to specify any particular points where it could be used better than at others.

The falls at Richmond constitute the first power on the stream, and extend over a distance of about 3 miles, the fall being 84 feet in that distance, the bed rocky, and the width of the stream from about one-eighth to one-quarter of a mile. From Grant's dam, at the head of the falls, and the first of the navigation dams, the canal extends without locks to the basin at Richmond, which is therefore 84 feet above tide. This is connected with the river below the falls by locks. Although considerable power is used at Richmond from the canal, there is also a large amount utilized from dams constructed below Grant's, so that in describing the powers it will be best to consider them in the order in which the dams occur as the river is ascended.

1. The first dam is the one which supplies power to the Haxall flour- and corn-mills. It extends from the north side of the stream in a very broken and zigzag line diagonally up the river from rock to rock, terminating in an island near the center of the stream, which is here perhaps 1,200 feet wide. A portion 330 feet long and 6 feet high was built of stone in 1880 at a cost of $2,500, while the remainder, about 1,200 feet long and 2½ feet high, is of wood. A race 500 yards long leads to the mill, where a fall of 22 feet is used, the power used being stated at 700 horse-power, which can be obtained during about ten months, while during the remaining two months about two-thirds as much can be obtained. The mills are run all the time, and at low water there is little or no waste over the dam. The pond covers only a few acres and affords no storage. In times of freshet, the machinery is sometimes stopped for a few days. The wooden dam is more or less injured by freshets almost every year, but there is seldom any trouble with ice; in 1879, however, the great ice-gorge below Richmond backed the water up into the mill. The mills of the Haxall-Crenshaw Company are the only ones using power from this dam.

2. The next dam is the one which supplies power to the various manufacturing establishments at Manchester, just opposite Richmond. The dam extends from the south bank in a very broken line diagonally up the river from rock to rock, ending just below the end of the Haxall dam. Its total length is about 1,650 feet, of which about 900 is of stone, and 3 or 4 feet high. About 50 feet of the stone part was built in 1878, and the rest about the year 1858 (said to have cost $2,570). The remainder of the dam is of wood. The pond is insignificant. A canal 500 or 600 yards long, 40 feet wide, and from 5 to 7 feet deep, leads from the dam, and along the lower part of this

canal are situated the mills mentioned below. The water-power is owned by the city of Manchester, and power is leased in 50-year leases at the rate of $4 per square inch of orifice under a head of 3 feet. No special precautions, however, are taken to regulate exactly the amount of water taken by each mill, and it seems that there is generally, except in very dry seasons, sufficient water for all the mills at present running. The following table gives the number of square inches paid for, and some other data. It is to be remarked that the price of $2 50 per square inch was formerly the regular rate, but it is now $4 for all new leases.

Table of power used at Manchester, Virginia.(*a*)

Proprietor or firm.	Kind of mill.	Number of square inches taken.	Price per square inch.	Total rent per annum.	Head and fall, in feet.	Horse-power used, net.	Number of months full capacity.	Capacity the rest of the time.	Number of hours per day run.	Steam-power used.
Martin Brothers & Baker	Sumac	150	$4 00	$600	14	30	*b* 12			
Richmond Cedar Works	Bucket	150	4 00	600	20	120	12		10	
Manchester paper-mill	Paper	300	4 00	1,200	19	100	12		24	
Old Dominion mill	Cotton	800	2 50	2,000	18	*c* 150	12		12	
Walker & Saunders	Flour	600	2 50	1,500	18	100	11	One-half	12	
Dunlop & McCance	do	800	2 50	2,000	20	200	12		24	
Marshall Manufacturing Company	Cotton	500	2 50	1,250	20	*d* 175	*e* 12		11	
Manchester corn-mill (*f*)	Corn				14	15–20	10–12			
City pump-works (*f*)					20	36				
						925				

a The figures giving the power used were obtained from the manufacturers, and may not be exact. The figures giving the amount of water taken and paid for were obtained from the city auditor. A calculation would probably show that the two statements do not agree in all cases, but the error could not be located without measurements.

b Sometimes obliged to stop on account of backwater.

c Power stated at 227 horse-power in returns of enumerators.

d Power stated at 140 horse-power in returns of enumerators.

e Average loss of about eight days on account of high water.

f Owned by the city.

The power available at the two dams just described would depend upon how the water could be distributed between the two and how much could be taken from the river above. The available power of the entire stream per foot fall can be seen by referring to the table on page 18.

3. The next dam is that of the Old Dominion Iron & Nail Works Company, and extends diagonally from the head of Belle Isle to the south bank of the river. The foot of the island is a quarter of a mile or so above the Manchester dam, and on the island are situated the works of the company. The dam is of wood and stone, about 3 feet high and from a quarter to a half mile long, and from it a canal about 400 yards long leads to the works, where the fall is from 16 to 18 feet. The power used is stated at 1,000 horse-power, and it is said that this amount can be secured during eight months of the year, the capacity during the remaining four months being about two-thirds as much.(*a*) The power is used to drive the rolling-mills. This dam is really a continuation of the one next to be described.

4. The Richmond water-works, on the north bank of the river, are supplied with power from a dam extending diagonally in a broken line, from rock to rock, to the head of Belle Isle. For the first 400 feet it is of stone, walled up in cement, about 6 feet high, and with a nearly vertical face. The remainder, about 800 feet, is of wood, not over 3 feet high. The stone part was built in 1844 at a cost of $13,000, and the wooden part in 1874 at a cost of $2,500. A race 700 feet long, 40 feet wide, and 6 feet deep leads to the wheels, where the fall is 10 feet. One turbine- and six breast-wheels are used to drive the pumps, the total power used being about 280 horse-power, and the amount of water taken by the city about 6,500,000 gallons per day, or about 10 cubic feet per second. Full capacity can be obtained during about ten months, and during the remainder of the time about one-half, there being little leakage or waste over the dam. A steam-pump of small capacity (800,000 gallons in twenty-four hours) is used in cases of emergency. The bed of the stream is very rocky, and the dam has never been carried away, although in the freshet of 1877 the water is said to have risen 26 feet at the works. The scarcity of water during the dry season has led to the establishment of new works, which will be referred to below.

5. The next dam is 3 miles above Richmond, and is known as Grant's dam, or Three-Mile dam. It is the first of the dams of the canal company, and was built as a feeder to supply the lower level with water, and not to afford slack-water navigation. It is 1,700 feet long and 4 feet high, extending only partly across the river, and is a wooden structure, built about 1854, and would probably cost $20,000. The Richmond level terminates below in the basin, which is connected by a series of 5 lift-locks with a dock which extends for a mile below the basin and is connected with tide-water by a ship-lock, thus enabling vessels to come up almost to the basin. The canal having now been abandoned, this lower level is free to be used to its full capacity for supplying water-power; but even while the canal was in use for navigation a number of manufacturing establishments were supplied with water-power from it.

a Power stated at 500 horse-power in enumerators' returns.

The use of navigation canals as a means of supplying water-power is limited, on account of the velocity of flow thereby occasioned; and as there are various other circumstances peculiar to this case, it may be well to say a few words regarding the power as it has heretofore been used. The dimensions of the canal are as follows: Width at top, 50 feet; width at bottom, 30 feet; depth, 5 feet; area of cross section, 200 square feet. According to the chief engineer of the canal, Mr. J. M. Harris, there has been and is now used for power from this lower level about 340 cubic feet per second, so that the velocity in the canal from this cause alone is 1.7 foot per second. This velocity has necessitated the use of a larger number of horses to haul the boats up the canal, and it has been concluded that a velocity of a mile per hour, or about 1½ foot per second, is the maximum which can be allowed on canals without considerable detriment to the interests of navigation. On account of the current it was proposed to enlarge the lower level of the canal, but the work was never carried out. In a report of the former chief engineer of the canal, Mr. Lorraine, "on the capacity of the first level for supplying water-power", it is stated that the cross-section could be enlarged to 300 square feet, making the top and bottom widths respectively 60 and 40 feet, and the depth 6 feet, so that, with a velocity of 1.5 foot per second, the capacity would be 450 cubic feet per second, affording 51 theoretical horse-power per foot fall. As regards power obtained from navigation canals, it is also to be borne in mind that the water is in some cases drawn off for a longer or shorter period for repairs, or during the winter. On the James River and Kanawha canal, however, the water was not drawn off during the winter and the mills obtained water almost uninterruptedly. There has sometimes been a little trouble with ice, but it is never serious. Water was rented by the company at the annual rate of $3 per cubic foot per second for each foot head and fall on the first level, while above the first level and below Lynchburg the rate was $1 10, and above Lynchburg and on North river it was 70 cents. Although these were the regular rates, there were some old agreements in some cases, rendering the details very complicated, and in some cases special rates were made, such as allowing to an establishment water free for five years, at half price for the following five, and at full price subsequently, in consideration of traffic brought to the canal. The amount of water delivered to each mill was regulated by the engineer of the company, and was delivered through an orifice accurately adjusted by him.

Postponing mention of the powers on the canal above Grant's dam, it remains to name those on the lower or Richmond level. They are as follows:

1. The Tredegar Company (rolling-mills, founderies, car-shops, machine-shops) use, according to Mr. Harris, about 122 cubic feet per second, discharging into the river below the city water-works and above the Haxall dam, with a fall of about 50 feet, in two falls of 23 and 27 feet. This would afford a theoretical power of 693 horse-power,(*a*) and full capacity can always be obtained.

2. Richmond Paper Manufacturing Company, using, according to Mr. Harris, 80 cubic feet per second, with a fall of about 21 feet, giving a theoretical power of 191 horse-power. (The enumerators' returns give the fall as 20 feet, and the power as 120 horse-power.) This water is ultimately discharged into the race leading to the Haxall mill, but before reaching it is used again by three different establishments, viz.:

a J. J. Montague's planing-mill, sash, blind, and door factory, using half the water coming from the paper-mill, with a fall of 20 or 21 feet, and 75 horse-power, which can always be secured. Steam-power to the extent of 65 horse-power is also used.

b T. W. McCance, jute-bagging factory, with 19 feet fall and 9 or 10 horse-power.

c Grist-mill, with 20 feet fall or thereabout; power about 25 horse-power.

3. The mills of the Gallego Mills Manufacturing Company (flour), situated at the lower end of the basin, are the last mills using water directly from the canal. They use, according to Mr. Harris, about 138 cubic feet per second, with a head and fall of 36½ feet, giving a theoretical power of 572 horse-power. The water is discharged eventually into the dock below the basin, after being used by the Gallego corn-mill and Whitehurst & Owen's sash- and blind-factory. There are 23 runs of stone in the flour-mill and 8 in the corn-mill, and full capacity can be secured generally during about half the year.

a The Gallego corn-mill uses a head and fall of 13½ feet, and perhaps about 80 to 100 horse-power, taking the water after it leaves the flour-mill.

b Whitehurst & Owen's planing-mill, and sash-, blind-, and door-factory use a fall of 16 feet and about 40 horse-power, and full capacity can always be secured, of course. The water is discharged to the dock after passing over a wheel formerly used for a paper-mill, with 7 feet fall. The ground, power, and mill are rented from the Gallego Company.

4. The Shockoe mills (corn, sumac, plaster, and bark), owned by Warner Moore, esq., take water from the dock, and discharge it into the river, using a fall of 14 feet and about 60 horse-power. No other mills take power from the dock, and this is therefore the lowest mill using power from the canal.

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a The power used was given, in a blank filled out by the company, at 1,100 horse-power. It is stated to be 829 horse-power in the enumerators' returns.

The power used from the canal on the Richmond level is therefore approximately as follows, assuming the efficiency of the wheels to be 75 per cent.:

	Net horse-power.
Tredegar Company	520 (?)
Richmond paper-mill	143 (?)
Montague's planing-mill	75
McCance's bagging-mill	10
Smith's grist-mill	25
Gallego flour-mill	430
Gallego corn-mill	80
Whitehurst & Owen's planing-mill	40
Moore's Shockoe mills	60
Total	1,383

The total power used from the James below Grant's dam is as follows, approximately:

	Net horse-power.
From the James River and Kanawha canal	1,383
City water-works	280
Old Dominion Iron Company	500 (?)
Manchester water-power	925
Haxall-Crenshaw Company	700
Total	3,788

These figures are liable to considerable error, but it is impossible to make them more accurate.

It is evident from the preceding description that the method of using the water-power at Richmond is rather complicated, and also that only a very small proportion of the total available power is at present utilized. There seems to be no technical reason why Richmond should not be one of the great manufacturing centers of the Atlantic slope, for it may safely be asserted that so far as water-power goes such advantages are seldom to be found. If all the water of the river could be diverted into the canal at Grant's dam its available fall at Richmond would be 84 feet at the lower end of the canal, while along the canal above the basin and above the Tredegar works is a strip of land which could be occupied by factories for a distance of between half a mile and a mile, or even more, with an average fall of 48 or 50 feet. A glance at the estimate of power below will show the large amount of power which could thus be rendered available. But even if it were not practicable—for legal or other reasons—to divert the entire flow, or a large part of it, above the city, a considerably larger amount of power could be utilized if the dams were raised and tightened, and extended entirely across the river. A detailed discussion of these points, however, does not belong here. It has been said that the Three-Mile dam could be raised several feet; but on the other hand, it is also asserted that this would be accompanied, in times of freshet, by damage to the Richmond and Danville railroad, which here follows the river.

The drainage area of the James above Richmond is about 6,800 square miles, and the average rainfall over the entire basin is probably about 42 or 43 inches, varying from 44 at Richmond to 38 in the mountains. Of this about 12 inches fall in spring, 12 in summer, 9 in autumn, and 10 in winter. The flow is very variable, as already mentioned, but no series of gaugings has been made. Two different measurements of the flow, however, made in very dry seasons, when the river was lower than for many years, and probably not far from its minimum stage, agreed quite well in giving the discharge at about 1,300 cubic feet per second. I have therefore estimated the power available as follows:

Table of available power of the James river at Richmond.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	50 *feet fall.*	84 *feet fall.*
Minimum	6,800	84	1,300	147.7	7,385	12,400
Minimum low season			1,500	170.4	8,520	14,300
Low season, dry years			1,750	200.0	10,000	16,800
Maximum with storage			6,000	681.8	34,000	57,000

It is not probable that any storage during the night could be obtained. The above figures, therefore, refer to power available during twenty-four hours.(*a*)

a During the summer and fall of 1881 the James river has been lower than for many years past. The mills on the canal and on the river have been obliged to run at a small fraction of their capacity, and it is stated that the river could be crossed almost anywhere along the falls without wetting one's feet. It is probable that the flow has fallen considerably below that given as the minimum, 1,300 cubic feet per second, or 0.19 cubic foot per second per square mile, and it is possible that it may have fallen nearly as low as in the case of the Potomac (0.093 cubic foot per second per square mile). Nevertheless, I have retained the figures given, having no accurate data regarding the flow in 1881.

The existing canal would carry perhaps 350 cubic feet per second with a fall of 1 foot per mile, and about 500 cubic feet per second with a fall of 2 feet per mile (supposing its dimensions to be 50 feet width at top, 30 feet at bottom, depth, 5 feet), and still more with a greater fall. If its dimensions were 60, 40, and 6 feet, it would carry perhaps 600 and 900 cubic feet per second with the declivities given above.

The following table gives the power which would be available under these conditions:

Section of canal.	Fall of bed per mile.	Estimated capacity of canal per second.	Horse-power available, gross.		
	Feet.	*Cubic feet.*	*1 foot fall.*	*50 feet fall.*	*80 feet fall.*
Width at surface, 50 feet; width at bottom, 30 feet; depth, 5 feet.	1	350	40.0	2,000	3,200
	2	500	56.8	2,840	4,544
Width at surface, 60 feet; width at bottom, 40 feet; depth, 6 feet.	1	600	68.2	3,410	5,456
	2	900	102.3	5,115	8,184

From what has been said it is evident that the advantages for the use of water-power at Richmond are very great. The facilities for transport, both by sea and by land, are scarcely surpassed; building-materials can be obtained near by, and an excellent quality of granite is quarried within a very short distance. In fact, almost every advantage seems to be here.(*a*)

There is no power taken from the river between Richmond and Lynchburg, a distance of 146 miles along the stream. The fall between these points is, as already stated, 513 feet from tide-water to the Lynchburg water-works dam, or 429 feet from the crest of Grant's dam. The latter figure gives an average fall of 2.94 feet per mile. Within this distance there are 6 canal dams, with a total height of about 60 feet, and this subtracted from 429 leaves 369 feet as the total fall between ponds, or an average of 2.53 feet per mile. Within this distance there are, no doubt, some falls and some sites that might be utilized for power, perhaps to a considerable extent, besides those on the canal and at the dams. But the fact that the canal is now abandoned as a means of communication, and that consequently almost the total fall of the stream from Richmond to Buchanan is available for power, with as much water as the canal will carry or could be made to carry, seemed to me to render a detailed examination of the stream unnecessary for the purposes of this report. It would seem to be in the power of the railroad company to offer the very finest inducements to manufacturers desiring to use water-power. Mills could be established at each dam and lock along the entire length of the canal where the conformation of the ground would permit, those at the dams using falls equal to the heights of the dams, and discharging the water into the river below, and those at the locks using falls equal to the lifts of the locks, and discharging the water into the lower levels, to be used again at the next lock below; and in favorable places mills might also be established along the canal, discharging the water into the river—withdrawing it, to be sure, from the lower levels and thus lessening the amount available at the locks. And by increasing the dimensions of the canal at suitable points a much greater amount of power could be utilized than is now available, until at the limit the whole fall of the stream, minus that which is sufficient to maintain the velocity in the canal (which may be taken as *not less than* 1 foot per mile, and probably more), would be available for power. It is scarcely necessary to do more than call attention to the large amount of power which could thus be rendered available. Scarcely any of it being utilized, the field is almost entirely open, and the location has only to be selected from among numerous good ones. A few remarks, however, regarding the capacity of canals of different dimensions may serve to convey a clearer idea of the circumstances of the case.

When water flows in open channels its velocity is due to the slope of its surface, not to that of the bed of the canal. If the bed be horizontal, as in many navigation canals, then, as any velocity must be accompanied by a slope of the water-surface, the depth will be smaller at the lower end of the channel than at the upper end, and the cross-section will vary from point to point. The motion thus becomes varied, as it is called, and the mathematical investigation of its laws more complex. For a rough calculation, however, the discharge may be considered the same as if the bed were inclined and parallel to the surface, and the section the same as it is at the lower end—especially as the capacity of the canal depends upon the number of bends on its course, and many other circumstances, all more or less uncertain. A tolerably close estimate for the discharge could be obtained in any particular case by a series of approximations; but it is evident from what has been said that on long levels the capacity will be considerably smaller than it would be if the bed were inclined, and it would probably be necessary to give the canal-bed a slope on many levels, or to raise the water at its head—proceedings which would either reduce the fall available at the locks, or necessitate the raising of the dams and the embankments. Assuming, however, that the fall of the bed of the canal is 1 and 2 feet per mile, then the capacity of the canal, the total available fall between Richmond and Lynchburg, and the total theoretical power between those points, are given in the following table.

a Between the years 1848 and 1868, the number of days during which the James River and Kanawha canal was closed by ice varied from 0 to 56, the average for the 20 years being 15 days.

The capacity of the canal is the same as previously given for the Richmond level, the same dimensions being assumed:

Section of canal.	Fall of bed per mile.	Fall between Richmond and Lynchburg.	Distance between Richmond and Lynchburg.	Available fall between Richmond and Lynchburg.	Estimated capacity of canal per second.	HORSE-POWER AVAILABLE, GROSS. Per foot fall.	Total.
	Feet.	*Feet.*	*Miles.*	*Feet.*	*Cubic feet.*		
Width at surface, 50 feet; width at bottom, 30 feet; depth, 5 feet.	1	429	146	283	350	40.0	11,320
	2			137	500	56.8	7,782
Width at surface, 60 feet; width at bottom, 40 feet; depth, 6 feet.	1			283	600	68.2	19,300
	2			137	900	102.3	14,015

The table shows that the total power available is about 40 per cent. greater with a fall of 1 foot per mile than with one of 2 feet. The table given on page 21 for the power at Lynchburg will show that the flow of the stream at that place is probably seldom less than 600 cubic feet per second, so that the power given in the table above could probably be realized if favorable ground for location could always be found. It is sufficient to call attention here to these figures as giving a rough idea of the power lying here unemployed.

Although there is no power used directly from the river between Richmond and Lynchburg, a certain amount is already used from the canal. The first power is just opposite Grant's dam, where there are two locks with 10 feet lift each. The water is passed round these locks, and the fall of 20 feet is used for the new water-works of the city of Richmond. The amount of water to be used was stated at 283 cubic feet per second, which would give 643 gross horse-power with a fall of 20 feet. The amount of water to be taken for supplying the city was stated at 12,000,000 gallons daily, with provision for an eventual increase.

Between the Richmond level and the Lynchburg level there are sixteen other establishments taking power from the canal, using in all about 278 cubic feet per second, for which $5,975 per annum is paid; but none of these establishments are of much importance. They are all, or nearly all, flour-, grist-, and saw-mills.

The table on pages 22 and 23 gives a list of the dams on the stream between Richmond and Lynchburg, as well as above, with their dimensions. All of these dams, except Grant's and Seven-Island, offer good sites for power, an approximate estimate of which will be found in the table on page 23. Regarding intermediate falls on the stream it is said that power could be obtained a short distance above Scottsville, and at Fallsburg, 1 mile above Warren, but I did not verify these statements. There are 51 lift-locks on the canal between Richmond and Lynchburg, averaging 8½ feet lift, and 4 guard-locks at the dams. At each of the lift-locks, according to what has been said, a certain amount of power could be utilized if the land is favorable for building.

The next place above Richmond where power is used to any considerable extent is at Lynchburg. The river has at this place a fall of about 23 or 24 feet in a distance of 4 miles, at the center of which, or rather below, is the city. The bed of the stream is rock and gravel, the channel is interspersed with islands, especially at the head of the fall, and the banks are favorable for building, being above all but the highest freshets, yet not steep. Power is used here in two ways—from the navigation canal, and from a second canal running parallel to the first, both supplied from the same dam. The south end of the dam is about 2 miles below the head of the falls, and from this point it extends very irregularly and diagonally across the river, reaching the opposite bank nearly 2 miles farther up stream, or near the head of the falls. From the south bank a stone dam, built as an arc of a circle with a chord of 120 feet and an ordinate at the center of about 20 feet, extends to the foot of an island. It was built in 1839, and is 12 feet high. From the head of this island a wooden dam extends nearly up and down stream, to the lower end of a second island, and in this way the dam is carried across the river from island to island. The wooden dams are generally not over 3 or 4 feet high and are not substantial. It is proposed to raise the stone dam 2 feet and to extend it straight across the river, the cost of this improvement having been estimated by Mr. Harris at about $60,000. From the Lynchburg level of the navigation canal nine establishments are supplied with water-power, using together about 391 cubic feet per second, with an average fall to the river of about 17 feet, giving therefore about 750 gross horse-power. The fall on this level from canal to river varies from about 13 feet at the dam to 22 or 23 feet at a point 2 miles below. The mills on the level are as follows:

	Horse-power.
Morris' barytes-mill, 17 feet fall	36
Hall's flour-mill	—
Heald's bark-mill, 16 feet fall	30
Snead & Winston's planing-mill, 16 feet fall	25
Lynchburg Iron Company's rolling-mill, 12 to 14 feet fall	40
Piedmont flour-mill, 12 feet fall	150
Piedmont corn-mill, 13 feet fall	40
Percival's machine-shop	—
Dabney's foundery	—
City flour-mill, 12 feet fall	200

The water-rents for these establishments amount to $3,295 30 annually.

The head-gates of the second canal are by the side of the guard-lock of the canal, between it and the river. The canal is about one-quarter of a mile long, and averages 30 feet in width and 5 to 6 feet in depth, but is very variable in section. On it are located the following mills, discharging their water into the river:

	Horse-power.
James River Foundery and Manufacturing Company, 11½ feet fall	20
J. P. Pettyjohn's planing-mill, 12 feet fall	40
R. S. Dawson's tobacco-box mill, 12 feet fall	15
Sumac-mill, 12 feet fall	18 to 20
City water-works, 12 feet fall	100
Total	195

The water-power from this canal is controlled by the city, but water is not leased at any regular rate, on account of old agreements and contracts. At present the city also controls the water-power from the navigation canal, according to some special agreement.

All the mills at Lynchburg are troubled sometimes by high-water, but the interruption from this cause does not exceed two weeks or thereabout in the year. The freshets of 1870 and 1877 did considerable damage to property, carrying away each time part of the dam (one of the small wooden dams), and in the latter year overflowing and breaking through the water-works race and carrying away considerable lumber. There is no trouble with ice, there being no liability to ice-jams in the river. During the dry season there is often scarcity of water, even on the navigation canal, but this is due to imperfections of the dams or want of sufficient capacity on the canals. On the water-works canal more trouble is experienced in this respect, some of the mills being able to run at full capacity only during eight months, and the capacity falling as low as between one-half and two-thirds in dry seasons.

The drainage area above Lynchburg is about 3,650 square miles, and the rainfall about 41 or 42 inches—12 in spring, 12 in summer, 8 in autumn, and 10 in winter. The minimum flow is stated by some engineers at 1,000 cubic feet per second, but I have no doubt that it is much less. In the absence of further measurements, I have estimated the flow and power as in the following table:

Estimate of flow and power at Lynchburg.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*13 feet fall.*	*22 feet fall.*
Minimum	3, 650	13–22	540	61. 3	797	1, 350
Minimum low season			650	73. 8	959	1, 625
Maximum with storage			3, 200	363. 6	4, 727	8, 000
Low season, dry years			740	84. 1	1, 093	1, 850

There seems to be no reason why the whole of the power could not be utilized, excepting, probably, the maximum with storage, regarding which it is impossible to state definitely whether sufficient reservoir room could be secured. As regards facilities for transportation, Lynchburg is very favorably situated, as the map shows. Already of importance, its manufactures could be greatly enlarged if the whole of the available power were properly utilized.

Between Lynchburg and Buchanan, the western terminus of the canal, water-power is used directly from the river at only one point, known as Irish falls, in Amherst county, where about 50 horse-power is used for an iron furnace, saw- and grist-mill. The dam is of crib-work, 1,200 feet long and about 8 feet high, backing the water half a mile, and the fall used is 9 feet, with a race of 400 yards. There is also very little power used from the canal, the quantity of water amounting to only 55 cubic feet per second, supplied to a rolling-mill. At each of the canal dams, however, and at various points along the canal, and at the locks, power could be used without difficulty. As the table on page 23 shows, there are in this distance 12 dams; 5 of these are of stone and 7 of timber, varying in length from about 400 to 800 feet and over, and in height from about 8 to 30 feet, at all or nearly all of which a large amount of power could be used. The total fall in the river between the points mentioned is 299 feet, or nearly 6 feet per mile. The following table is similar to that on page 20:

Section of canal.	Fall of bed per mile.	Fall between Lynchburg and Buchanan.	Distance between Lynchburg and Buchanan.	Available fall.	Estimated capacity of canal per second.	Horse-power available, gross.	
						Per foot fall.	Total.
	Feet.	*Feet.*	*Miles.*	*Feet.*	*Cubic feet.*		
Width at surface, 50 feet; width at bottom 30 feet; depth, 5 feet	1	299	50	249	*a* 350	40. 0	9, 960
	2			199	500	56. 8	11, 303
Width at surface, 60 feet; width at bottom, 40 feet; depth, 6 feet	1			249	600	68. 2	16, 982
	2			199	909	102. 3	20, 358

a The flow of stream in dry weather is probably not 350 cubic feet per second except in lower portion of the distance.

In this case, however, the enlarging of the canal would, without doubt, be exceedingly expensive; but as the minimum flow at Lynchburg is, according to the table on page 21, only 540 cubic feet per second, and probably only about 330 cubic feet per second at Buchanan, the enlargement would practically be unadvisable. The principal locations on this section of the canal would seem to be at the dams, and estimates of the power at these places are given on page 23. These dams are very substantial structures, the stone ones being built up in hydraulic cement with nearly vertical faces, and the wooden ones being composed of crib-pens filled with stone, with sloping tops and backs and almost vertical faces, sheeted behind and on top, and all being founded on rock.(*a*) The Richmond and Alleghany railroad, when completed, will afford a most convenient means of transportation along the river, and it is needless to say that building materials are to be had in great abundance and of fine quality.

From Buchanan to the head of the river—the junction of Jackson's and Cowpasture rivers—the distance is about 29 miles and the fall about 202 feet, or at the rate of about 7 feet per mile. No power whatever is used on this part of the stream, although there are numerous sites where power could be obtained. The declivity of the stream being tolerably uniform, there are no precipitous falls, but at numerous points dams could easily and advantageously be located. It was at one time intended to continue the canal up the river and over the Alleghenies, and all the upper part of the James and part of Jackson's river were surveyed with this object in view, and the locations for two dams between Buchanan and the head of the dam were determined upon and the dams themselves partially constructed. One, the Cabell dam, 9 miles above Buchanan, was built to a height of 5 feet entirely across the river, being constructed of wood on a rock foundation; and the other, at the Old Forge, 15 miles above Buchanan, to be built entirely of stone, was not carried quite so far. At the former place, which is about 2 miles above Saltpetre Cave station, on the railroad, the banks are good, and a dam could be built probably 8 feet high, while for a mile below there is some fall which might be worth utilizing, so that with a canal half a mile long, probably a fall of 10 or 12 feet could be used, while with a shorter race 8 or 10 feet could probably be easily obtained. At the Old Forge, about 1½ mile above Salisbury Furnace, it would be easy to utilize power on the left bank, and probably from 6 to 10 feet could be rendered available. None of the other sites seem of much importance, though there are a number of rifts where power could be developed, but at no place, it is said, is there a fall of over 4 or 5 feet. The fall is gradual, the bed and banks gravel, clay, sand, etc., with rock at a small depth in most places. The river in this part of its course is, on the average, perhaps 250 or 300 feet wide. Although no power is at present used, there have been in times past several grist-mills above Buchanan, but none using large powers.

The following tables give the statistics of dams and of power utilized, and estimates of the power available at the dams. Regarding the latter, it is to be mentioned that Mr. E. Lorraine, the late chief engineer of the canal, in a report made in 1866, "on the points at which water-power can be spared from the dams and canal", does not mention Judith's or Blue Ridge dam; and it may be that the land at those localities is not favorable for location.

Table of statistics regarding dams of the James River and Kanawha Canal Company on the James river.

[Heights given above foundation and above water-surface.]

Name of dam.	DAM.						POND.		Remarks.
	Distance from Richmond.	Length.	Height.	Material.	Date of erection.	Cost.	Length.	Whether used for navigation.	
	Miles.	*Feet.*	*Feet.*				*Miles.*		
Grant's	3.0	1,700	4	Wood	1855 (?)	$20,000	....	Feeder only	Dam does not extend entirely across river. No water-power.
Bosher's	9.0	902	{12 / 9}	Cut granite in cement	1857-'58	70,000	10	Navigation	
Maiden's Adventure	29.0	1,026	{12 / 10}	Cut granite in cement	1852-'53	80,000	5	5 miles navigation.	
Seven-Island	....	....	....	Wood	1840	....	....	Feeder only	Low dam. Enables boats to enter canal from other side of river. Does not extend entirely across. No water-power.
Tye River	109.0	550	{12 / 10}	Cut granite in cement	1860	60,000	....	2½ miles navigation.	
Joshua Falls	135.5	600	{12 / 9}	Cut granite in cement	1870	50,000	3	2½ miles navigation.	Rebuilt in 1870.
Lynchburg	148.5	....	....	Part stone, part wood	1839	....	2	2 miles navigation.	Extends in a broken line from island to island.
Judith's	152.0	725	{33 / 25}	Cut stone in cement	1850-'51	100,000 or over.	4	4 miles navigation.	
Bald Eagle	157.0	498	{14 / 14}	Cut stone in cement	1849-'51	35,000	2½	2½ miles navigation.	

a On this section of the canal (Lynchburg to Buchanan) there are 22 miles of canal, 28 miles of slack-water navigation, 38 locks, 2 aqueducts, 17 tow-path bridges, and two farm bridges.

Table of statistics regarding dams of the James River and Kanawha Canal Company on the James river—Continued.

Name of dam.	DAM.						POND.		Remarks.
	Distance from Richmond.	Length.	Height.	Material.	Date of erection.	Cost.	Length.	Whether used for navigation.	
	Miles.	*Feet.*	*Feet.*				*Miles.*		
Pedlar	160.0	454	{ 18, 12 }	Cut stone in cement	1849-'51	$35,000	2	2 miles navigation.	
Coleman's Falls	162.5	572	{ 18, 14 }	218 feet stone, 354 feet wood.	1849-'51	30,000	3	3 miles navigation.	
Big Island	166.5	683	{ 12, 12 }	Stone	1849-'51	35,000	2	2 miles navigation.	
Cushaw	170.5	843	{ 10, 10 }	Wood	1849-'51	20,000	1	....	Boats cross river in pond.
Blue Ridge	176.0	455	13	150 feet stone, 305 feet wood.	1849-'51	20,000	3 and 1½	{ 3 miles on James, 1½ miles on North }	{ At confluence of North river. Stone part in front of old wooden part. }
Quarry Falls	178.5	582	{ 13, 13 }	136 feet stone, 446 feet wood.	1849-'51	25,000	2½	2½ miles navigation.	Not very favorable for power.
Varney's Falls	185.5	488	{ 18, 14 }	Wood	1849-'51	20,000	3	3 miles navigation.	Not so favorable for power as the two below.
Indian Rock	189.5	613	{ 19, 16 }	Wood	1849-'51	30,000	3	3 miles navigation.	Easy to utilize for water-power.
Wasp Rock	194.0	384	{ 20, 15 }	Wood	1849-'51	30,000	3	3 miles navigation.	Easy to utilize for water-power.

James river—Table of power available at Richmond and at canal dams.

Locality.	Distance from Richmond.	Drainage area.	RAINFALL.					TOTAL FALL.		HORSE-POWER AVAILABLE, GROSS. (a)				UTILIZED.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum with storage.	Low season, dry years.	Horse-power, net.	Fall.	
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Miles.*						*Feet.*	
Richmond	0.0	6,800	12	12	9	10	43	84	3	12,400	14,300	57,000	16,800	3,765	....	
Bosher's dam	9.0	6,760	12	12	9	10	43	9	0	1,300	1,500	6,000	1,750	0	....	
Maiden's Adventure dam	29.0	6,560	12	12	9	10	43	10	0	1,400	1,650	6,600	1,900	0	....	
Tye River dam	109.0	4,350	12	12	9	10	43	10	0	750	900	4,350	1,150	0	....	
Joshua Falls dam	135.5	3,750	12	12	9	10	43	9	0	575	700	3,400	800	0	....	
Lynchburg	148.5	3,650	12	12	8	10	42	13-22	0-2	{ 800, 1,350 }	950, 1,625	4,700, 8,000	1,100, 1,850	} 750±	12-16	
Judith's dam	152.0	3,525	12	12	8	10	42	25	0	1,500	1,800	8,800	2,050	0	....	
Bald Eagle dam	157.0	3,475	11	12	8	10	41	14	0	850	1,000	4,800	1,150	0	....	Some power used from canal, but none directly at the dams.
Pedlar dam	160.0	3,475	11	12	8	10	41	12	0	700	850	4,200	970	0	....	
Coleman's Falls dam	162.5	3,345	11	12	8	10	41	14	0	800	950	4,700	1,100	0	....	
Big Island dam	166.5	3,285	11	12	8	10	41	12	0	675	800	3,950	900	0	....	
Cushaw dam	170.5	3,265	11	12	8	10	41	10	0	550	650	3,250	750	0	....	
Blue Ridge dam	176.0	3,245	11	12	8	9	40	13	0	700	850	4,200	975	0	....	
Quarry Falls dam	178.5	2,400	11	12	8	9	40	13	0	525	625	3,100	700	0	....	
Varney's Falls dam	185.5	2,375	11	12	8	9	40	14	0	550	650	3,350	750	0	....	
Indian Rock dam	189.5	2,340	11	12	8	9	40	16	0	650	775	3,750	900	0	....	
Wasp Rock dam	194.0	2,300	11	12	8	9	40	15	0	575	700	3,500	800	0	....	
Buchanan	198.0	2,200	11	12	8	9	40	....	....	....	....	....	....	....	....	

a See pages 8 to 11.

TRIBUTARIES OF THE JAMES RIVER.

The first important tributary of the James is the Chickahominy, which enters from the north, on the boundary line between the counties of Charles City and James City, after having pursued a course of about 50 miles, measured in a straight line, and draining an area of about 412 square miles. But though important by reason of its size, it is altogether without water-power. Taking its rise just about on the fall-line, it is sluggish and altogether unfavorable for power for its entire length.

The next tributary, and the most important affluent of the James, is the Appomattox, which enters from the south between Chesterfield and Prince George counties. It takes its rise in Appomattox county, and pursues a general easterly direction, forming the boundary line between the counties of Buckingham, Cumberland, Powhatan, and Chesterfield on the north, and Prince Edward, Amelia, Dinwiddie, and Prince George on the south, and flowing

through the town of Petersburg, where it crosses the fall-line, giving rise to a fine water-power at that place, which is the head of navigation and of tide-water. The length of the stream, measured in a straight line, is about 85 miles, but by the river it is considerably greater, the distance from tide-water to a point 38½ miles above Farmville, and therefore probably not far from the source of the stream, being about 135 miles.(*a*) The river drains an area of about 1,565 square miles, of which 1,325 are above Petersburg. The principal tributaries of the stream are: Swift creek, which enters from the north, below Petersburg, after draining about 165 square miles; Deep creek and Flat creek, which enter from the south, in Amelia county, and drain, respectively, 173 and 112 square miles. The drainage basin of the Appomattox lies entirely east of the Blue ridge, in the middle and eastern divisions of the state, and seems to offer no peculiarities. It contains no lakes; the rainfall averages about 43 inches—12 in spring, 12 in summer, 10 in autumn, and 9 in winter; and the stream is similar in all essential respects to the James in corresponding parts of its course. Like that river, it is subject to sudden and heavy freshets, but they are said to be rather less violent than those on the former stream; and the flow of the Appomattox is said to be on the whole more uniform and proportionally greater in dry seasons than that of the James—facts which find their explanation in part in the distribution of the rainfall.

The following table gives an idea of the declivity of the stream:

Table of declivity of the Appomattox river.

Locality.	Distance from tide-water.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Petersburg					
			6.25	110	17.60
Lowest dam of Upper Appomattox Company	6.25	110			
			47.75	65	1.36
Richmond and Danville Railroad crossing	54±	175			
			38.00	90	2.40
Atlantic, Mississippi, and Ohio Railroad first crossing	92±	265			
			5.00	35	7.00
Atlantic, Mississippi and Ohio Railroad second crossing	97±	300			

This table is in many respects inaccurate, the distances having been roughly measured from a map; but it serves to show that the declivity is small above the falls at Petersburg, being even smaller than that of the James. The stream is, moreover, quite inaccessible between Petersburg and Farmville, and its water-power—whatever there may be of it—is not extensively used above the former place.

As already mentioned, Petersburg is at the head of tide-water, and vessels drawing 11 feet of water come up to the city. In this respect the stream resembles the James, the fall-line being at the head of tide and navigation. Above Petersburg, navigation has been carried on by flat-boats, the river having been made navigable long ago by the Upper Appomattox Company—still in existence—which has the chartered right to navigate the stream up to Farmville. It is said that the river is susceptible of being made navigable by bateaux carrying 20,000 pounds up to Plantersville, 16 miles above Farmville, and that navigation was at one time established up to this point; but that part of it above Farmville was abandoned some thirty years ago on account of the building of the railroad. At present, navigation extends up to Clementown, 70 miles above Petersburg, and it is said that it could be extended to Farmville at small cost; but above this the stream is very small. At the present time the river is navigated only to a small extent, the railroad having absorbed most of the traffic, although it is often a number of miles from the stream. The navigation works consist of locks and dams, and one canal extending from Petersburg to the lowest dam, a distance of 5¼ miles, with a fall in that distance of about 32 feet, (*a*) overcome by locks. Above this is a series of dams, converting the river into a series of navigable pools. The locks are 60 feet long, 10 feet wide, with lifts of 7 feet, and there are 8 dams between Petersburg and Clementown.

Describing the powers on the river in their order, the first is that at Petersburg. According to what has been said, the fall from the canal basin at Petersburg to tide-water is 77½ feet, the fall on the canal 32 feet, and the fall from the lowest navigation dam to tide—in a distance of 6¼ miles—about 110 feet. (*a*) The principal part of this fall, however, occurs in the first mile or two above tide-water, amounting to 70 or 80 feet, and is used by various establishments, supplied from 4 dams:

1. The lowest dam—1¼ mile above the head of navigation and about 13 miles from the James—is 350 feet long and 8 feet high, and is a crib-work structure extending in the shape of a > across the stream. It has been built many years, and supplies power to the following establishments:

a. Williams' corn- and sumac-mill and cotton-gin—10 feet fall; 45 horse-power; full capacity during eight months, rest of the year one-third.

b. City flour-mills (Davis, Roper, & Co.)—10 feet fall; 100 horse-power; full capacity eight to nine months, rest of the year one-third.

c. Jones & Co.'s sumac- and bark-mill—10 feet fall; 30 horse-power; full capacity twelve months.

a Twenty-seventh Report of Board of Public Works of Virginia.

These mills run night and day and are all on the south side of the river. In the summer and fall, when the stream is lowest, there is no water wasted, and even then it seems that there is a great lack of water. It will be be noticed hereafter that a portion of the water of the river is diverted several miles above, at the lowest navigation dam, passing through the canal, and affording power to several mills in Petersburg. These mills, however, discharge their tail-water into the pond of the dam which has just been described, so that the mills above mentioned use the entire flow of the stream.

2. The second dam is also of crib-work, 400 feet long and 6 feet high, originally built about the year 1835, but rebuilt in 1865 at a cost of $3,000, and ponding the water for about a quarter of a mile. From it two races about a quarter of a mile long, one on each side of the river, lead to the mills, which are situated at the head of the pond below:

a. Eagle mills, corn and flour—17 feet fall; 80 horse-power; full capacity eight months; one-half capacity ten months; one-fourth capacity twelve months.

b. Eames' saw- and planing-mill, sash and blind factory—16 feet fall; 20 horse-power; full capacity nine months; one-half capacity twelve months.

c. Allen's corn-mill and cotton-gin—17½ feet fall; 45 horse-power.

d. Powhatan mill, flour and corn—16 feet fall; 50 horse-power.

The above are all on the north side of the river. On the south side are the following:

a. Kevan's flour-mill—14 feet fall; 80 horse-power; full capacity nearly all the time.

b. "Merchants'" cotton factory—closed since 1875; ran 2,500 spindles and 100 looms; fall 14 feet. This mill was run wholly or in part by water taken from the canal of the Upper Appomattox Company, and therefore diverted from the river over 5 miles above.

It is stated that although in summer no water wastes over the dam, yet the mills have to run at a small fraction of their full capacity during several months.

3. The third dam is of wood and stone, some 700 feet long and 5 or 6 feet high, and supplies power to the cotton-mill of the Ettrick Manufacturing Company on the north side of the river, and to that of the Battersea Manufacturing Company on the south side. The former uses a fall of 17½ feet and an estimated power of 200 horse-power; the latter uses 12 feet fall and 140 horse-power. Both mills run between eleven and twelve hours per day, but the pond is not large enough to store the water completely at night. In summer there is no waste during the day-time. Full capacity can be secured during about eight months, averaging from two-thirds to three-fourths during the rest of the year.

4. The fourth dam is of wood and stone, about 300 feet long and 2½ feet high, and supplies power to the cotton-mill of the Matoaca Manufacturing Company on the north side of the river. The fall is 16 feet and the power 265 horse-power. In summer there is no waste during the day-time, but the pond is not large enough to store the water completely during the night, the mill being run eleven hours. Full capacity can be secured nine months, and three-fourths during the remaining three months.

None of the mills referred to use steam except the Matoaca, which has reserve steam for periods of low water. There is little unimproved fall between these dams. Notwithstanding the freshets, there is no trouble in maintaining the dams, the bed of the stream being rock. The banks are close and shelving, but not steep, and the facilities for constructing canals and buildings are everywhere good. During freshets the mills are sometimes obliged to stop running for a few days, but there is little or no trouble with ice.

5. The fifth dam is the lowest navigation dam, which diverts part of the water into the canal, so that the mills above mentioned, except those fed from the first dam (and Kevan's flour-mill), obtain only what water flows over the navigation dam. How much water the navigation company may turn into its canal is a question not decided. Leaving the river about 5 miles west of Petersburg, the canal conducts to the basin at the city, which is the lowest point that can be reached by boats. The dam at the head of the canal extends entirely across the river, which is here divided into two arms by an island; its total length is about 400 feet and its height 4 or 5 feet; its crest is 109 or 110 feet above low tide. About half-way between the dam and the basin, or 2 miles west of the city, is a flight of four locks, with together a fall of 32 feet. At these locks there are two powers of about 15 feet each; the upper one was used during the war by the Confederate government for a powder-mill, and the lower one was used until very recently for a snuff-mill, but is now idle. The entire fall of 32 feet, it would seem, could easily be utilized for power, if necessary. From the basin at Petersburg, which is about 77 feet above low tide, the water which comes down the canal passes to the river, driving in succession several mills, as follows:

1. Munts' grist-mill—fall about 14 feet; about 50 (?) horse-power.
2. Box factory, with a fall of about 2 feet, run by an undershot wheel driven by the tail-water from Munts' mill.
3. The Lynch cotton-mill—fall 14 or 16 feet; about 100 horse-power.
4. Davis, Roper, & Co.'s cotton-mill—fall about 16 feet, with an overshot wheel; about 70 horse-power.

From the latter mill the water flows into the race leading to Kevan's flour-mill. It was formerly utilized to run the "Merchants'" cotton-mill, which had a fall of 14 to 16 feet, and is said to have used about 125 horse-power, but which is now not in operation, and for sale. Kevan's flour-mill, however, as well as the mills from the lowest dam on the river, use this water.

All the mills using power from the canal can run at full capacity during about nine months; during the remaining three months the capacity falls to from one-half to three-fourths; none of them use any steam-power.

As regards the method of renting power, Munts' mill and the box factory belong to the persons running them, and the power is rented from the canal company according to special agreement, and with no regular rates. The other mills now running are owned by the canal company, and are rented, with the power, according to special contract. The Merchants' mill was owned and operated by a stock company, the power only being rented from the canal company.

Recapitulating, then, the power used from the Appomattox in the 6 miles of its course above tide-water is as follows:

	Feet fall.	Horse-power, net.
From first dam:		
Williams' corn- and sumac-mill	10	45
City flour-mills	10	100
Jones' sumac- and bark-mill	10	30
Total		175
From second dam:		
Eagle mills	17	80
Saw- and planing-mill, etc	16	20
Allen's corn-mill	17½	45
Powhatan flour- and corn-mill	16	50
Kevan's flour-mill	14	80
Merchants' cotton factory	14	....
Total first and second dams		450
From third dam:		
Ettrick cotton factory (*a*)	17½	200
Battersea cotton factory (*b*)	12	140
Total		790
From fourth dam:		
Matoaca cotton factory (*c*)	16	265
Total		1,055
From fifth (navigation) dam:		
Venable's snuff-mill	15	....
Munts' grist-mill	14	50
Box factory	2	(?)
Lynch cotton factory	16	100
Davis, Roper, & Co. (*d*)	16	70
Total from river		1,275

The drainage area above Petersburg has already been stated to be 1,325 square miles, and the rainfall at 43 inches (page 24). The flow and power may therefore be estimated as follows, in the entire absence of gaugings:

Table of estimated power of the Appomattox river at Petersburg.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.			Remarks.
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*77 feet fall.*	*110 feet fall.*	
Minimum	1,325	*a*77½–*b*110	175	20.0	1,540	2,200	Probably not available.
Minimum low season			200	22.7	1,750	2,500	
Maximum with storage			1,100	125.0	9,625	13,750	
Low season, dry years			235	26.7	2,050	2,940	

a Basin to tide. *b* Dam No. 5 to tide.

It would probably be impracticable to increase this power to any great extent by concentrating it into fewer than twenty-four hours. It will be seen that in all probability, if the entire fall of the stream from the navigation dam to tide-water were well utilized, about 3,000 gross horse-power could reasonably be expected during the low season of tolerably dry years. The table just given shows that probably little over one-half of this power is at present utilized. The power is an excellent one, with the best advantages of transportation, both by sea and by land.

Above Petersburg the stream is controlled as far as Farmville by the navigation company, but I have found it impossible to obtain complete details regarding the dams, mills, and powers not utilized. It is said, however—and

a Power stated at 205 horse-power in returns of enumerators.
b Power stated at 160 horse-power in returns of enumerators.
c Power stated at 313 horse-power in returns of enumerators.
d Power stated at 70 horse-power in returns of enumerators.

it seems altogether probable—that a certain amount of power can be used at each of the 8 canal dams below Clementown. How much water would be available would depend upon the amount needed for locking boats through, regarding which I have no data on which to base estimates; but as only few boats at present navigate the river, it is probable that nearly the entire flow of the stream could be utilized for power. For want of data regarding heights of dams and their locations I present no estimates. It was stated, however, that the lift of the locks was 7 feet, so that this would probably be the average height of the dams. Some of the power at the dams is at present utilized, but details could not be obtained. From one of the dams the Exeter mills, on the south side of the river, were formerly supplied, but the buildings were burned down some eight years ago, and the site is not now used, though it is said to be one of the best above Petersburg. At Farmville there is a grist-mill, and a few small ones are above, none of consequence.

The tributaries of the Appomattox, although they have some power, are not of much importance. Swift creek has one power worth mentioning, at Chesterfield city, the Swift Creek cotton factory, using 75 horse-power, with a fall of 3 (?) feet (according to the returns of the enumerators), and using all the water of the stream in summer. Full capacity can be secured during about nine months, and one-half during the remainder of the year. There are also several grist-mills on the stream. Regarding the other tributaries I have no detailed information.

The next considerable tributary to the James is Willis river, from the south, but its fall is gradual, and no unemployed sites of importance were spoken of.

The Rivanna river, the next large tributary, is formed in Albemarle county by the union of the North and South forks, both of which rise on the eastern slope of the Blue ridge, in Greene and Albemarle counties; and from their junction it pursues a southeasterly course, passing within a mile of Charlottesville, the county-seat of Albemarle county, and entering the James river in Fluvanna county, near the town of Columbia. It drains a total area of 668 square miles, the North fork draining 164 and the South fork 226, comprising a hilly and rolling region, and it has considerable fall, although the declivity is quite gradual. The bed is generally sand and gravel, with rock a short distance below, and sometimes on the surface. There are no lakes, and the stream is, like all the others in the vicinity, subject to sudden and heavy freshets, which, however, are of brief duration. The rainfall on the basin is about 43 inches—12 in spring, 13 in summer, 8 in autumn, and 10 in winter. The flow of the stream has never, so far as I could learn, been accurately gauged. Its fall from the junction of the two forks to its mouth—a distance of 40 miles—is 135 feet, according to an old survey.(a) Up to Milton, 32 miles, the stream was made navigable, over 50 years ago, by means of dams and locks, some of which are in existence, many in bad condition, and some of which are at present used for water-power. At present the stream is navigable for a distance of about 23 miles from its mouth. Its elevation at the crossing of the Chesapeake and Ohio railroad, a few miles from Charlottesville, is 278 feet above mean tide. The map shows that the stream is accessible at its mouth from the Richmond and Alleghany railroad, and in the neighborhood of Charlottesville from the Chesapeake and Ohio railroad and the Virginia Midland railroad.

The first power on the stream is 5 miles from its mouth, at the second navigation dam, known as Stillman's, with a fall of 16 (?) feet, 25 horse-power being used for a flour-mill, the drainage area above being about 650 square miles. I should estimate the flow and power as follows, there being no gaugings of the flow:

Table of estimated power at mouth of Rivanna river.

State of flow (see pages 8 to 11).	Fall.	Drainage area.	Flow per second.	Horse-power available, gross.	
	Feet.	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*16 feet fall.*
Minimum	16	650	75	8.5	135
Minimum low season			90	10.2	160
Maximum with storage			600	68.0	1,100
Low season, dry years			110	12.5	200

Although the original navigation works were built over 50 years ago, I am informed that the present dam was built in 1855 at a cost of $30,000, being a crib-dam 350 feet long and 18 feet (?) high, backing the water 6 miles. There was formerly one dam below this point, with a fall of 5 or 6 feet.

Six or 7 miles above is the Carysbrook dam, with a fall of about 8 feet, used by a grist-mill. The available power would be rather less than half that estimated in the above table.

The third is the Palmyra dam, about 10 miles above Stillman's. It is 250 feet long, about 12 feet high, and a fall of 12½ feet is utilized by a flour-mill. The drainage area above is about 630 square miles, so that the available power per foot will be only very little less than at Stillman's dam.

Three miles above Palmyra is the Broken Island dam, with a canal perhaps a quarter of a mile long, and a fall of 10 or 12 feet, not utilized. The available power per foot is probably about the same as in the table above.

Three miles still farther up is Bernardsburg dam, said to have a canal nearly 2 miles long, and a total fall of somewhere about 15 feet, not used for power.

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a Eleventh Report of Board of Public Works of Virginia.

Union dam, 2 miles farther up, is about 200 feet long and 10 feet high, constructed mostly of stone, and is said to have cost $10,000. It was built in 1850. A race of 600 feet affords a fall of 12 feet, used for a corn-mill and a small cotton factory (the latter idle since about 1866), only a small amount of power being utilized. The drainage area above this place is about 500 square miles. The power available may be estimated with sufficient accuracy from the table preceding, by taking the horse-power per foot as about eight-tenths of that there given.

Three and a half miles above Union dam is the Buck Island dam, a crib-work structure 200 or 300 feet long and 10 or 12 feet high. It was formerly used by a cotton factory which is not now in use. The drainage area is but slightly less than that above Union dam.

Stump Island dam, which is the next, is used by a small grist-mill with a fall of about 6 feet. The dam is of crib-work, about 400 feet long and 6 feet high, and backs the water nearly up to the next dam.

Milton dam, about 12 miles above Union dam, is a crib-work dam about 200 feet long and 4 feet high. A race of a quarter of a mile affords a fall of 11 feet at a grist-mill with four runs of stones. The flow here is about the same as at Shadwell, so that the power can be calculated from the table below. This site is for sale.

It will be seen that up to this dam—which, so far as I could learn, is the last of the original navigation dams—there are 9 dams, of which 3 are not used for power, while at the remaining 6 a portion of the available power is utilized. A summary of the available power (estimated) at these dams is given in tabular form farther on. Many of the dams being leaky, however, the power given could rarely be secured, even if correctly estimated.

A mile or two above Milton is the most important unimproved site on the river—the former site of the Shadwell factory. The available fall here is about 20 feet in a distance of $2\frac{1}{4}$ miles. The bed is rock, the stream is about 300 feet wide, and the facilities for dams, races, and buildings are very good, as a personal examination showed. The old dam was 6 or 7 feet high, and the race a quarter of a mile long, giving a fall of 18 feet or thereabout at the mill, the principal part of the fall occurring at the lower end of the shoal. The site is a good one, and I have estimated the power as follows:

Table of estimated power at Shadwell.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*18 feet fall.*
Minimum	448	18 to 20	45	5.1	90
Minimum low season			60	6.8	125
Maximum with storage			400	45.5	820
Low season, dry years			70	8.0	145

This power is very conveniently located directly on the railroad.

At the head of the old Shadwell pond, or $2\frac{1}{4}$ miles above the foot of the falls, is the most important utilized power on the river, the Charlottesville woolen-mills, situated $1\frac{1}{2}$ mile from the city. The dam is of cut sandstone, about 200 feet long and 10 or 12 feet high, built about the year 1855. A race 600 feet long and 15 feet wide leads to the mill, where the fall is 12 feet. The power used is said to be about 60 horse-power, with a waste of water at all times. The power is a good one, and is very conveniently located on the line of the railroad.

Between this point and the forks of the river there are no important powers utilized or available, though there is one site, at Pen Park, where it is said some power could be developed, though it has never been employed.

The two forks of the Rivanna, with their tributaries, offer some good sites for small powers, and are utilized by numerous saw- and grist-mills. Their fall is rapid, and the bed and banks are generally favorable. None of the powers, however, are large enough to run more than two pairs of stones, in dry weather, with the wheels in use.

The following table gives the drainage area and fall at each dam on the stream, with the best practicable estimates of the power, since no gaugings have been made:

Summary of power on Rivanna river.

Locality.	Drainage area.	Fall.	Horse-power available, gross.			
			Minimum.	Minimum low season.	Low season, dry years.	Maximum with storage.
	Sq. miles.	*Feet.*				
Stillman's dam	650	16(?)	135	160	200	1,100
Carysbrook dam	640	8	65	80	100	550
Palmyra dam	640	$12\frac{1}{2}$	100	120	150	850
Broken Island dam	550±	8–10	50	65	80	475
Bernardsburg dam	525±	15±(?)	90	115	140	825
Union dam	505	12	70	90	110	650
Buck Island dam	490±	8–10	45	60	70	430
Stump Island dam	470±	6	35	45	50	300
Milton dam	450	11	60	75	90	525

Between the Rivanna river and the North river, the next tributary of the James worthy of a special description, a number of streams enter, all having the same general characteristics. Their declivities are gradual; their beds gravel and sand, with occasional rock ledges; their flow quite variable, and they are all utilized to some extent by saw- and grist-mills, generally with dams. There are probably sites on all of them where power can be obtained by damming, but no natural falls. Such are Slate river, from the south; Hardware river, Rockfish river, Tye river, and Pedlar river, from the north, besides a number of smaller streams from both sides. On a small tributary entering at Lynchburg is a car-shop of the Atlantic, Mississippi, and Ohio railroad, with a fall of 12 feet and about 20 horse-power, but with this exception all the power used is for grist- and saw-mills, the former with two or three pairs of stones, as a rule. Some of these streams have considerable fall, Rockfish river, for instance, having a fall of 250 feet in the lower 28 miles of its course, or about 9 feet per mile, according to an old survey.

North river takes its rise in the northern part of Rockbridge county, where it is formed by the union of the Great Calfpasture and Little Calfpasture, both of which streams rise in the mountains of Augusta county, and pursue courses a little west of south, draining narrow and parallel valleys. From their junction the North river pursues a nearly southerly course, first cutting through a gap in the mountains to reach the broader valley separating the Blue ridge on the east from North mountain on the west, and thence pursuing its course through this valley, receiving as tributaries South river and Buffalo creek, and entering the James in the southeastern corner of Rockbridge county, just above where the river cuts through the Blue ridge. It flows through the town of Lexington, the county-seat of Rockbridge county, a flourishing town noted for its educational institutions; and it drains a total area of 784 square miles, distributed as follows: Great Calfpasture, 140; Little Calfpasture, 41; Buffalo river, 161; South river, 150. Of this area a large portion lies in the valley between the Blue ridge and North mountain, and the remainder is a hilly and mountainous region among the parallel ranges which form the western part of Rockbridge and Augusta counties. There are no lakes in the basin, and the flow of the stream is quite variable. The character of its bed is the same as that of the other tributaries of the James. The rainfall on the basin is about 40 inches—11 in spring, 11 in summer, 9 in autumn, and 9 in winter. The stream has a very considerable fall, which is not so gradual as in the case of many tributaries of the James. The following table shows the declivity:

Table of declivity of the North river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	706	20	188	9.4
Lexington	20	894	30±	485	16.1±
Great Calfpasture crossing of the Chesapeake and Ohio railroad	50±	1,379			
Little Calfpasture crossing of the Chesapeake and Ohio railroad		1,491			

Above Lexington the fall is very rapid, especially where the stream passes through the gap in the mountains from the valley of the Calfpasture, where there is a rapid fall over a rocky bed for several miles, perhaps at the rate of from 30 to 50 feet per mile.

The fact that the North river is quite inaccessible has no doubt prevented the development of its water-power. Until the construction of the Richmond and Alleghany railroad, which follows the James past the mouth of the river, it was impossible to reach it except from Goshen, on the Chesapeake and Ohio railroad, from which place a stage runs to Lexington, or by taking a canal-boat from Lynchburg, between which place and Lexington boats run every two days. A branch of the James River canal extends up the North river to the latter place, and it is possible that a branch of the railroad may be built along the tow path, as is being done on the James. There are, besides, several other railroads in contemplation, all passing through Lexington, so that it seems probable that the disadvantage of inaccessibility will before long be removed.

Between the mouth of the river and Lexington there are 10 navigation dams and 24 locks, varying in lift from 7 to 17 feet. With one exception the dams are built of rubble limestone, without cement, sheeted on top and behind with timber, and varying in length from 250 to 450 feet, and in height from 8 to 20 feet. They were all built in the years 1852 and 1853. Within the distance referred to there are about 10 miles of canal, the remainder being slackwater navigation. Should the canal on this river be superseded entirely by the railroad, as on the James, there seems to be no reason why a large amount of power could not be utilized at the locks and dams. In order, however, to utilize the entire flow of the stream, the dams would probably have to be tightened. According to Mr. Harris, "all the dams offer good sites for power". According to Mr. Lorraine's report "on the capacity of the canal to furnish water-power, and on the expediency of making grants generally", navigation on the river at that time was such that "on the North River canal no water-power can be spared till the dams are made tight". A personal examination showed, however, that if the dams are tightened, and if all the flow of the stream is not needed for navigation, there are numerous excellent sites for power. At present very little is utilized, as the table

on page 33 will show, there being only a few small flour-mills, a cement-mill, and others, each with perhaps 20 or 30 horse-power. In order to give some idea of the power available, I have estimated the flow and power at the mouth and at Lexington.

Estimated power of the North river.

State of flow (see pages 8 to 11).	AT MOUTH.			AT LEXINGTON.		
	Drainage area.	Flow per second.	Horse-power available, gross.	Drainage area.	Flow per second.	Horse-power available, gross.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*
Minimum	784	80	9.0	416	50	5.7
Minimum low season		100	11.4		60	6.8
Maximum with storage		700	80.0		375	42.5
Low season, dry years		125	14.2		75	8.5

If it is desired to estimate roughly the total power available between those points, the flow may be taken as the mean of that at the two places, and the fall as perhaps 150 feet, the results being as follows: Minimum, 1,100 horse-power; minimum low season, 1,360 horse-power; low season, dry years, 1,700 horse-power; maximum with storage, 9,200 horse-power. The flow at Lexington was measured in the low-season of 1876, by W. G. McDowell, civil engineer, who found it to be about 121 cubic feet per second. This measurement is undoubtedly accurate; but if this flow is the minimum, the stream must be very different in character from the other streams of Virginia. At the same place the river is said to have risen 25 feet in the freshet of 1870. It may be that springs in the drainage basin render the flow of the stream more constant than would be expected, and all mere estimates are of course sometimes liable to be far from the truth.

Above Lexington, notwithstanding the rapid fall, little power is used, but grist- and saw-mills are scattered here and there on the tributaries. Where the river cuts through the gap in the mountains the fall, though large, is not well available. Buffalo and South rivers are similar in character to North river, and no details regarding their power could be obtained.

The other tributaries of the James below the forks are small streams draining a mountainous country, often with rapid fall, and in some cases with cataracts or rapids. None of them are utilized except by small grist- or saw-mills and a furnace or two. Power might be developed on all of them, but it would fluctuate greatly in amount.

The head-waters of the James, Cowpasture, and Jackson's rivers resemble the North river in all essential respects; their fall is quite rapid, but very little power is utilized. As regards bed and banks, there is no difficulty, but no rapids of importance occur on them except in perhaps one or two instances. The Cowpasture takes its rise in Highland county, flows through Bath and Alleghany and joins Jackson's river in Botetourt. Its length in a straight line is about 50 miles and its drainage area 580 square miles. Regarding its flow and declivity no data could be obtained. It has numerous small shoals, but none with falls of over 4 or 5 feet in a short distance. Its power is utilized only by grist- and saw-mills, with falls of from 6 to 10 feet, all with dams. Jackson's river takes its rise in Highland county, and flows generally parallel to the Cowpasture, and through the same counties. Its length is about 65 miles along its general course, and its drainage area about 981 square miles. It flows through the towns of Covington and Clifton Forge, and between these places it is followed by the Chesapeake and Ohio railroad. Above Covington, however, it is very inaccessible. Regarding its declivity and flow no accurate data are at hand. From Buchanan, on the James, to Clifton Forge, about 2 or 3 miles above the mouth of the Cowpasture—a distance of 32 or 33 miles—the fall is 221 feet, or about 7 feet per mile; and between Clifton Forge and Covington—a distance of 15 miles—the fall is 167 feet, or about 11 feet per mile. The rainfall on the basin, as well as on that of the Cowpasture, is about 38 inches—11 in spring, 11 in summer, 8 in autumn, and 8 in winter. Estimates of the flow at Covington and at Clifton Forge are given farther on. The shoals on Jackson's river seem to be more numerous and to have greater fall than those on the Cowpasture, although this may be due to the greater amount of information which could be obtained regarding the former stream.

The first power met with in ascending the river is at Clifton Forge, at which place there is a dam 10 feet high and 290 feet long, built in 1874, of crib-work, at a cost of $2,800, and founded on solid rock. It was formerly used for a grist-mill, but at present no power is utilized. The river at this place passes through a rocky gorge in the range of mountains which separates its valley from the adjacent one, and for half a mile below the dam—which is at the upper end of the gorge—the banks are steep and the power is difficult to utilize, as all the available space is occupied by the Richmond and Alleghany railroad, which passes through the gorge, on the south side, to its terminus just above. No race could be built without blasting it out on the north side of the river, or building a high wall on the south side between the race and the river. The site may therefore be called practically unavailable. The dam backs the water about three-quarters of a mile, with an average width of 250 feet. Between this point and Covington there are several shoals where power might be developed. At one point, a few miles above Clifton Forge, there was once a mill, washed out in the freshet of 1877. About 6 miles by road below Covington there is another shoal, where a fall of several feet could be obtained; and 5 miles below Covington, at Island Ford, a fall of 6 to 8 feet is

probably available, while there are several other small shoals below Covington. At the latter place there is a mill using about 60 horse-power with a fall of about 7½ feet, and a dam 7 feet high and 325 feet long, built of logs, like most of the dams in the vicinity. Full capacity can be obtained during only nine months, with two breast-wheels, and sometimes only half capacity can be secured, all the water of the stream being utilized. At this mill the water rose 22½ feet during the great freshet of November, 1877, which was the largest ever known on the river.

Above Covington the width of the stream averages 150 feet for some distance, and its fall is rapid but gradual. There are several mills using power from it, but all are small. Among the shoals, the one best known is at the Narrows, about 14 miles above Covington, where the fall is said to be 8 feet or so in a few hundred yards, the place being very rocky and the power difficult to utilize.

Of the tributaries to Jackson's river the following may be mentioned: Warm Spring run, which has one mill with a fall of about 28 feet, and a carding-mill, with 14 feet; the temperature of the water is 90° F.; Hot spring, a small stream with a temperature of 110° F.; Back creek, with several saw- and grist-mills, but said to be unfavorable for power by reason of a sandy and shifting bed; Mill creek, with a cascade near the mouth, about 8 miles north of Covington; Dunlap's creek, along which the Chesapeake and Ohio railroad runs after leaving the river, a stream said to be exceedingly variable in flow, and of no value for power, almost drying up in summer, although it drains 194 square miles; and, finally, Potts' creek, draining 152 square miles, a rapid stream, said to offer considerable undeveloped power and to be a good mill-stream.

Table of estimated flow and power at Clifton Forge and at Covington.

State of flow (see pages 8 to 11).	CLIFTON FORGE.					COVINGTON.				
	Drainage area.	Fall.	Flow per second.	Gross horse-power.		Drainage area.	Fall.	Flow per second.	Gross horse-power.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*10 feet fall.*	*Sq. miles.*	*Feet.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*
Minimum	925	10	100	11.3	110	675	7+	75	8.5	60
Minimum low season			150	17.0	170			110	12.5	90
Maximum with storage			820	93.2	930			600	68.2	475
Low season, dry years			175	20.0	200			130	14.8	100

In recalling what has been said regarding the James river and tributaries one can not fail to be struck with the large amount of power lying idle, and yet easily available, on the main stream and on North river along the line of the canal. Dams and races built and almost ready for use, transportation as convenient as could possibly be wished, the railroad passing by the very door, a healthful climate, abundance of building materials of good quality—all these advantages are combined in a way seldom found. There is no doubt, however, that the flow of the stream is very variable, and the establishment of large storage reservoirs impracticable.

The following table gives the statistics of utilized power in the basin:

Table of utilized power of the James river and tributaries.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.	Remarks.
						Feet.		
James river	Chesapeake bay	Virginia	Henrico	Flour and grist	1	22	700	
Do	do	do	do	do	1	36½	430	
Do	do	do	do	do	3	47½	165	
Do	do	do	do	Planing, etc	2	36	105	From canal.
Do	do	do	do	Bagging	1	19	10	
Do	do	do	do	Paper	1	20	120	
Do	do	do	do	Iron-works	1	50	(?)520	From canal (see description).
Do	do	do	do	Water-works	1	10	280	
Do	do	do	do	do	1	20	480	From canal.
Do	do	do	do	Nails, etc	1	18	(?) 500	
Do	do	do	do	Blast-furnace	1	22	......	Not in operation.
Do	do	do	Chesterfield	Cotton	2	38	325	
Do	do	do	do	Water-works	1	20	36	
Do	do	do	do	Paper	1	19	100	
Do	do	do	do	Bucket	1	20	120	
Do	do	do	do	Sumac	1	14	30	
Do	do	do	do	Flour and grist	3	52	320	
Do	do	do	Goochland	do	2	37	116	
Do	do	do	Fluvanna	do	4	56	69	Probably from canal.
Do	do	do	Albemarle	do	1	10	30	
Do	do	do	Nelson	do	1	9	20	

Table of utilized power of the James river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.	Remarks.
						Feet.		
James river	Chesapeake bay	Virginia	Campbell	Flour and grist	4	37+	400	
Do	...do	...do	...do	Barytes	1	17	36	
Do	...do	...do	...do	Bark	1	16	30	From canal.
Do	...do	...do	...do	Furniture	1	16	25	
Do	...do	...do	...do	Rolling-mill, etc	1	12–14	40	
Do	...do	...do	...do	Steel company	1	22	......	
Do	...do	...do	...do	Foundery	1	11½	20	
Do	...do	...do	...do	Planing	1	12	40	
Do	...do	...do	...do	Tobacco-box	1	12	15	From water-works canal.
Do	...do	...do	...do	Sumac	1	12	20	
Do	...do	...do	...do	Water-works	1	12	100	
Do	...do	...do	...do	Woolen	1	17	(?)40	
Do	...do	...do	Amherst	Iron-works	1	9		
Do	...do	...do	...do	Saw	1	9	50	
Do	...do	...do	...do	Grist	1	9		
Do	...do	...do	Bedford	Rolling-mill	1	......	......	From canal.
Do	...do	...do	Rockbridge	Flour and grist	2	31	16	
Do	...do	...do	...do	Cement	1	9	20	From canal.
Tributaries of	James river	...do	Isle of Wight	Flour and grist	1	8	50	
Do	...do	...do	Prince George	...do	3	44	70	
Chickahominy river	...do	...do	Hanover	...do	2	28	65	
Do	...do	...do	...do	Saw	1	14	25	
Tributaries of	...do	...do	James City	Flour and grist	4	51	52	
Do	...do	...do	Charles City	...do	4	76	56	
Do	...do	...do	Henrico	...do	5	......	91	
Do	...do	...do	...do	Sumac	1	24	40	
Do	...do	...do	Hanover	Saw	2	39	30	
Do	...do	...do	...do	Flour and grist	6	80	105	
Do	...do	...do	Chesterfield (*a*)	...do	3	40	58	
Do	...do	...do	...do	Saw	1	17½	5	
Do	...do	...do	Powhatan	Flour and grist	6	89	92	
Do	...do	...do	...do	Saw	3	......	79	
Do	...do	...do	Goochland	...do	3	40	30	
Do	...do	...do	...do	Flour and grist	12	177	181	
Do	...do	...do	Cumberland	...do	7	107	153	
Do	...do	...do	...do	Saw	3	......	78	
Do	...do	...do	Buckingham	...do	8	118	147	
Do	...do	...do	...do	Wheelwrighting	1	7	4	
Do	...do	...do	...do	Flour and grist	21	350	475	
Do	...do	...do	Appomattox	...do	2	24	28	
Do	...do	...do	Campbell	...do	9	156	268	
Do	...do	...do	...do	Woolen	1	17	20	
Do	...do	...do	...do	Saw	2	26	60	
Do	...do	...do	Bedford	...do	1	16	10	
Do	...do	...do	...do	Woolen	1	......	5	
Do	...do	...do	...do	Flour and grist	7	104	100	
Do	...do	...do	Roanoke	Woolen	1	22	12	
Rivanna river	...do	...do	Fluvanna	Flour and grist	3	41	73	
Do	...do	...do	Albemarle	...do	5	58	109	
Do	...do	...do	...do	Woolen	1	12	60	
Tributaries of	Rivanna river	...do	Fluvanna	Flour and grist	6	68	51	
Do	...do	...do	...do	Sumac	1	25	31	
Do	...do	...do	Albemarle	Saw	6	......	71	
Do	...do	...do	...do	Woolen	1	22	8	
Do	...do	...do	...do	Flour and grist	12	177	212	
Do	...do	...do	Greene	...do	7	113	89	
Do	James river	...do	...do	Saw	1	19	16	
Do	...do	...do	...do	Agricultural implements.	1	20	45	
Do	...do	...do	...do	Flour and grist	10	169	161	
Rockfish river	...do	...do	Nelson	...do	7	105	122	
Do	...do	...do	...do	Saw	4	56	79	
Tributaries of	Rockfish river	...do	...do	...do	1	18	20	
Do	...do	...do	...do	Flour and grist	4	63	84	
Do	...do	...do	...do	Leather	1	18	18	
Tye river	James river	...do	...do	Flour and grist	3	......	59	

a For Appomattox river and tributaries, see below.

Table of utilized power of the James river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.	Remarks.
						Feet.		
Tributaries of	Tye river	Virginia	Nelson	Flour and grist	4	......	60	
Do	...do	...do	Amherst	...do	7	105	115	
Do	James river	...do	...do	...do	8	126	127	
Do	...do	...do	...do	Saw	4	59	[illegible]	
Do	...do	...do	Botetourt	Blacksmithing	1	12	6	
Do	...do	...do	...do	Foundery	1	23	10	
Do	...do	...do	...do	Flour and grist	28	554	408	
Do	...do	...do	...do	Saw	20	388	250	
Do	...do	...do	...do	Wool	1	16	12	
Do	...do	...do	...do	Blast-furnace	1	20	20	Not in operation.
Do	...do	...do	Craig	Flour and grist	5	74	86	
Do	...do	...do	...do	Saw	4	50	42	
Do	...do	...do	...do	Furniture	1	12	5	
Do	...do	...do	...do	Foundery	1	......	6	
North river	...do	...do	Rockbridge	Flour and grist	10	148	162	
Do	...do	...do	...do	Saw	1	20	8	
Tributaries of	North river	...do	...do	...do	5	......	48	
Do	...do	...do	...do	Agricultural implements.	1	40	8	
Do	...do	...do	...do	Wheelwrighting	1	25	12	
Do	...do	...do	...do	Furniture	1	26	12	
Do	...do	...do	...do	Flour and grist	22	392	344	
Do	...do	...do	...do	Wool	1	16	12	
Do	...do	...do	Augusta	Flour and grist	2	43	34	
Do	James river	...do	Rockbridge	...do	1	20	20	
Do	...do	...do	...do	Blast-furnace	1	......	20	Not in operation.
Jackson's river	...do	...do	Alleghany	Flour and grist	1	6	35	
Do	...do	...do	...do	Saw	1	6	8	
Tributaries of	Jackson's river	...do	...do	Flour and grist	2	25	26	
Do	...do	...do	Bath	...do	1	20	12	
Do	...do	...do	...do	Wool	1	......	......	
Cowpasture river	James river	...do	...do	...do	1	7	12	
Do	...do	...do	Highland	...do	2	34	19	
Tributaries of	Cowpasture river	...do	Alleghany	Blast-furnace	1	78	30	
Do	...do	...do	Bath	Flour and grist	2	30	28	
Do	...do	...do	...do	Blast-furnace	1	15	20	Not in operation.
Do	...do	...do	Highland	Flour and grist	4	80	42	
Appomattox river	James river	...do	Chesterfield	...do	3	50	175	
Do	...do	...do	...do	Sash, doors, etc	1	16	20	
Do	...do	...do	...do	Cotton	2	33	165	
Do	...do	...do	Dinwiddie	...do	3	44	310	
Do	...do	...do	...do	Flour and grist	4	48	275	Petersburg.
Do	...do	...do	...do	...do	2	38	18	
Do	...do	...do	...do	Sumac	1	10	30	Petersburg.
Do	...do	...do	...do	Snuff	1	......	20	Petersburg—not in operation.
Do	...do	...do	...do	Box	1	2	......	Petersburg.
Do	...do	...do	Amelia	Flour and grist	3	66	39	
Do	...do	...do	...do	Saw	2	58	20	
Do	...do	...do	Powhatan	...do	1	4½	7	
Do	...do	...do	...do	Flour and grist	2	10½	26	
Do	...do	...do	Cumberland	...do	2	13½	40	
Do	...do	...do	Prince Edward	...do	2	19½	40	
Do	...do	...do	...do	Saw	1	6½	10	
Tributaries of	Appomattox river	...do	Chesterfield	...do	1	12	18	
Do	...do	...do	...do	Flour and grist	5	80½	62	
Do	...do	...do	...do	Cotton	1	3	75	
Do	...do	...do	Nottoway	Flour and grist	3	56	58	
Do	...do	...do	...do	Saw	1	16	12	
Do	...do	...do	Amelia	...do	1	16	8	
Do	...do	...do	...do	Flour and grist	9	138	137	
Do	...do	...do	Powhatan	...do	1	15	18	
Do	...do	...do	Cumberland	...do	2	24	22	
Do	...do	...do	Buckingham	...do	1	......	10	
Do	...do	...do	Prince Edward	...do	8	......	100	
Do	...do	...do	...do	Saw	1	25	15	
Do	...do	...do	Appomattox	...do	3	30	30	
Do	...do	...do	...do	Flour and grist	6	91	87	

II.—THE YORK RIVER.

The York river, the next important stream north of the James, is a broad and navigable stream for its entire length, about 35 miles, and offers no power. It is formed by the union of the Pamunkey and Mattapony rivers, and flows in a southeasterly direction between the counties of Gloucester and King and Queen on its left, and New Kent, James City, and York on its right, emptying into Chesapeake bay. At the head of the river is the town of West Point, connected by a railroad with Richmond, and the general government has appropriated $10,000 for the purpose of improving navigation up to this point, the present project contemplating the establishment of a navigable depth at all times of 22 feet. The ruling depth at low tide is now 19 feet, and at high tide 22 feet. The stream lies entirely below the fall-line.

The Pamunkey river, which with the Mattapony forms the York, is itself formed by the union of two streams—the North Anna and South Anna rivers—which unite not far from the fall-line, so that the Pamunkey lies almost wholly, if not wholly, in the eastern or tide-water division of the state. It pursues a general southeasterly course, is about 40 miles long, measured in a straight line, and drains a total area of about 1,313 square miles. In the upper part of its course (above Hanovertown) it is narrow and very tortuous, and much obstructed by logs and trees, while below that point it is navigable to a certain extent, and it might be made so above. The banks of the river are bold, and even precipitous in places, and have an average height of 50 feet. The extreme rise of the river in freshets is 22 feet.(*a*) There is no power whatever on the stream. The South Anna river, one of its head-waters, rises in Albemarle county, near the sources of the Rivanna, and flows in a southeasterly direction through Louisa and Hanover counties, to join the North Anna. Its drainage area measures about 440 square miles, and lies almost wholly above the fall-line; yet I was unable to learn of any power of importance on the stream, and the table on page 35 will show that if there is much, only a small proportion is utilized. At its crossing with the Richmond, Fredericksburg, and Potomac railroad, only a mile or two above its mouth, the stream has an elevation above tide of but 50 feet,(*b*) so that the fall of the Pamunkey must be very small. No information could be obtained regarding any power where the stream crosses the fall-line. The North Anna river, a stream similar to the one just referred to, rises in Orange county and flows southeast between Spottsylvania and Caroline on its left, and Louisa and Hanover counties on its right, to join the South Anna. It drains a total area of about 504 square miles, and its length in a straight line is about 40 miles. Its elevation at the crossing of the Richmond, Fredericksburg, and Potomac railroad is also 50 feet above tide. According to an old survey, the fall of the stream between its mouth and the junction of its north and south forks, the distance being a little over 49 miles, is 164½ feet, or about 3.4 feet per mile.(*c*) In this distance there were, at the time of the survey, 10 mills with falls of from 7 to 14 feet each, using together a fall of about 96 feet. Above the junction of the two forks the fall was found on one of them to be about 50 feet in 15 miles, or at about the same rate as below, and in this distance there were two mills, with, together, about 16 feet fall. As in the case of the South Anna, I was not able to gain any information regarding any large fall on the river at the place where it crosses the fall-line, or at any other place. In the report above referred to, mention is made of the Great falls, but they seem to be where the stream is small, and of no value for power. No information could be obtained regarding them, nor could I even learn where they are located.

The Mattapony river rises in Spottsylvania county, and pursues a southeasterly course through Caroline and between King and Queen and King William counties, joining the Pamunkey at West Point. Its length in a straight line measures about 70 miles, and it drains an area of 846 square miles, a considerable portion of which lies below the fall-line. The stream is navigable for about 50 miles, and can be improved so as to afford navigation for lighters or barges for a distance of 25 or 30 miles farther, or a total distance of 80 miles.(*d*) The fall of the stream between tide-water and Milford, near where the fall-line is crossed, in a distance of 48 miles, has been found to be 73 feet, or at the rate of 1.5 foot per mile. The elevation at the crossing of the Richmond, Fredericksburg, and Potomac railroad is 70 feet. I was unable to learn of any powers of importance on the stream.

The average rainfall on the entire drainage basin of the York river is about 44 inches—12 in spring, 14 in summer, 8 in autumn, and 10 in winter. Estimates of the flow and power are unnecessary. The statistics of power utilized are given in the following table:

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a *Annual Report of the Chief of Engineers*, 1880, p. 773.

b I am indebted for the elevations on the Richmond, Fredericksburg, and Potomac railroad to Major E. T. D. Myers, general superintendent.

c *Thirteenth Report of Board of Public Works of Virginia*, 1828, p. 311.

d *Annual Report of the Chief of Engineers*, 1880, p. 771.

Table of utilized power of the York river.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net
						Feet.	
Mattapony river	York river	Virginia	King William	Flour and grist (*a*)	4	65	65
Do	do	do	King and Queen	do	[illegible]	44	75
Do	do	do	do	Saw	1	15	35
Do	do	do	Caroline	do	1	7	10
Do	do	do	do	Flour and grist	2	25	30
Tributaries of	Mattapony river	do	do	do	11	155	135
Do	do	do	do	Saw	[illegible]	25	28
Do	do	do	Spottsylvania	do	4	55	48
Do	do	do	do	Flour and grist	9	109	106
Pamunkey river	York river	do					
North Anna river	Pamunkey river	do	Caroline	Flour and grist	5	41	48
Do	do	do	do	Saw	2	18	28
Do	do	do	Louisa	do	1	4	9
Do	do	do	do	Flour and grist	[illegible]	30	60
Do	do	do	Spottsylvania	do	1	9	28
South Anna river	do	do	Hanover	do	6	52	121
Do	do	do	Louisa	do	9	72	160
Do	do	do	do	Saw	1	9	12
Other tributaries of	York river	do	Orange	Flour and grist	2	36	85
Do	do	do	Louisa	do	8	135	90
Do	do	do	do	Saw	1	26	12
Do	do	do	Spottsylvania	Flour and grist	1	10	16
Do	do	do	Hanover	do	9	93	111
Do	do	do	Caroline	do	3	70	36
Do	do	do	do	Saw	1	22	23
Do	do	do	King William	Flour and grist	2		40
Do	do	do	King and Queen	do	7	[illegible]	105
Do	do	do	do	Saw	1	7	7
Do	do	do	New Kent	Flour and grist	[illegible]	106	120
Do	do	do	do	Agricultural implements	1	16	16
Do	do	do	James City	Flour and grist	2	24	18
Do	do	do	York	do	5	56	68
Do	do	do	do	Saw	1		18
Do	do	do	Gloucester	do	1	12	18
Do	do	do	do	Flour and grist	1	13	12

a Perhaps on tributaries.

III.—THE RAPPAHANNOCK RIVER.

The Rappahannock river takes its rise in Rappahannock and Fauquier counties, Virginia, on the eastern slope of the Blue ridge, and flows in a southeasterly direction through a fertile and hilly country belonging to the middle, or Piedmont, section of the state, forming the boundary line between the counties of Fauquier and Stafford on its left, and Rappahannock, Culpeper, and Spottsylvania on its right. At the city of Fredericksburg it crosses the fall-line with a considerable fall and a large amount of power, and below that point it is a sluggish, tidal, and navigable stream, spreading out sometimes to a width of several miles, and forming the boundary line between the counties of King George, Westmoreland, Richmond, and Lancaster on its left, and Caroline, Essex, and Middlesex on its right. It empties into Chesapeake bay at a point about 36 miles from cape Charles. The length of its course in a straight line is about 132 miles, and it drains a total area of about 2,700 square miles. Its principal tributary is the Rapidan river, which enters from the right, 10 or 12 miles above Fredericksburg, and drains an area of about 745 square miles. The only town of importance on the river is Fredericksburg, with a good water-power and several mills and factories, which will be fully described. Up to this place, 104 miles from the mouth of the river, there is a navigable depth of 9 feet at low tide and 12 feet at high tide, and the river is now being improved by the government to secure a navigable depth of 10 feet. Many years ago the river was made navigable as far as Waterloo, in Fauquier county, a distance of 50 or 60 miles above Fredericksburg, by means of locks, dams, and canals,

terminating at the lower end in the basin at Fredericksburg. These old navigation works, however, having long been disused, except in one or two places, have been mostly destroyed. The locks still exist in many places, but the dams are nearly all gone. The works will be described in detail in the proper place.

There are no lakes in the basin of the Rappahannock, and the flow of the stream is very variable, but no records of gaugings could be found, and resort was therefore had to estimates. The bed of the stream is generally rock overlaid with gravel and sand, and the banks generally high enough to confine the river, except in high freshets—there being comparatively few bottoms subject to overflow, as in the case of the more southern streams. The slope of the stream is not uniform, but is broken by considerable falls at several places, at which good water-power could be secured. The elevation of the stream above tide at Fredericksburg is zero, and at the crossing of the Virginia Midland railroad, 35½ miles above, it is 252 feet, showing a fall at the rate of 7.1 feet per mile. The rainfall on the basin is about 42 inches, of which about 12 fall in spring, 13 in summer, 8 in autumn, and 9 in winter. The small fall in autumn must have for its effect a corresponding variability in the flow, which would seem even more pronounced than in the case of the James.

The accompanying map shows that the river is crossed by two railroads, the Richmond, Fredericksburg, and Potomac, and the Virginia Midland. Between the two it can not be called very accessible, and any utilization of the water-power to a large extent would probably require a better means of communication than exists at present.

The first power occurs at Fredericksburg—the crossing of the fall-line—and, as in the case of the James, this point is the head of tide-water and of navigation. The dam is located about 2 miles above the city, at the head of the falls, and extends straight across the river. It is a crib-work structure, 900 feet long and 18 feet high, bolted to the rock which forms the foundation, and backing the water about a mile with an average width of 600 feet. It was built in 1860 by Mr. John Chase, of Holyoke, Massachusetts, and is said to have cost $60,000. From it a race, about 1½ mile long, 30 or 40 feet wide, and 5 or 6 feet deep, leads to the basin at the upper edge of the city, between which and the river there is a fall of 48½ feet, which is used in two parts. From the basin or upper level two mills are fed, as follows:

1. Washington woolen-mill (Kern, Bentley, & Co.); 18 feet fall; 45 horse-power, with two turbine wheels.
2. "Germania" flour-mills (Myer & Brülle); 23 or 24 feet fall; 50 or 60 horse-power (?), with three turbines; 8 runs of stones.

Both these mills discharge their water to the second or lower level, from which the following mills take it, discharging into the river:

3. R. K. Knox & Brothers' sumac- and bone-mill; 18 feet fall; 50 to 60 horse-power.
4. J. B. Ficklen & Sons' "Bridgewater flour- and corn-mill"; 21 feet fall; 110 horse-power, with three turbines and 9 runs of stones.
5. There was formerly a paper-mill using water directly from the basin, with a fall of 12 feet, and discharging its water through a separate tail-race, at the lower end of which, a mile below, and just where the railroad crosses the river, it was again used, and discharged into the river by the—
6. Excelsior mill (Thomas & Pettit), now running as before, although the paper-mill has not been in operation for some years. This mill has 5 runs of stones, and uses 50 to 60 horse-power, with a fall of 28 feet, and an overshot wheel.

These mills can generally run at full capacity during the entire year, so far as amount of water is concerned, but those discharging directly into the river are sometimes obliged to stop because of high water. The flour-mills run night and day. The power is controlled by the Fredericksburg Water Power Company (L. S. White, president, Baltimore, Maryland), and is leased by them at the rate of from $5 to $15 per horse-power (net?) per annum, according to the level from which it is taken and the amount taken. There being at present generally an excess of power, no care is taken to measure exactly the amount used by each mill. The following are the amounts paid for and the prices:

	Horse-power.	Per annum.
Germania mills	50	$750
Woolen mill	60	....
Thomas & Pettit's flour-mill	50	500
Knox's sumac-mill	60	0
Ficklen's flour-mill	110	120
Total used	330±	

In the case of the last two mills a certain amount of power is secured to them by prior rights.

The land around the basin is very favorable for the development of power and for the construction of buildings and races. The interruption from freshets occurs so seldom as to be of little consequence, and there is very little trouble with ice. The dam has never been carried away or injured. The entire cost of the works, including dam, canals, land, etc., was about $250,000, but the canal was already built—being the old navigation canal—and had only to be repaired and raised.

The drainage area above Fredericksburg is about 1,600 square miles, and the rainfall about 42 inches—12 in spring, 13 in summer, 8 in autumn, and 9 in winter. In the absence of gaugings I have estimated the power as follows:

Table of estimated power of the Rappahannock river at Fredericksburg.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross. (*a*)	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	48 *feet fall.*
Minimum	1,600	48+	176	20.0	960
Minimum low season			220	25.0	1,200
Maximum with storage			1,414	160.7	7,700
Low season, dry years			250	28.4	1,360

a At present utilized, 300 to 400 horse-power net, or say 550 horse-power gross.

In their circular the company claims 4,000 horse-power, said to be based on Mr. Chase's report, but the stage of the water is not specified. It was stated to me, however, that in dry weather the water even now falls 6 or 8 inches below the level of the crest of the dam, the entire flow being diverted into the canal; that in dry years there is no waste at all during two months or more in working-hours; and that when the paper-mill (referred to as No. 5) was running, and using about 75 horse-power, there was one summer when the mills could not obtain full capacity. Still, with economical utilization of the fall and good motors, a considerably larger amount of power than is now used could no doubt be rendered available even in the driest seasons, and in ordinary seasons much more. It is also probable that the power can be and is increased to some extent by storing the water during the night, as the pond is large enough to store several hours' flow in the driest seasons. It is stated that in winter there are generally 8 or 10 inches of water on the dam, in large freshets 10 feet, and in ordinary freshets 5 or 6 feet. As regards the maximum available with storage, it is probable that sites for reservoirs can be found in the upper valleys, though probably not by any means sufficient to render the whole available.

The power at Fredericksburg, though not large, comparatively, is deserving of attention as being very conveniently located. The facilities for transportation by water and by land are excellent.

As regards the river for 25 or 30 miles above Fredericksburg, I have been able to collect information quite in detail regarding the old navigation works, but regarding particular sites for power not much could be learned, except in one case. From a description of the locks and dams formerly existing, however, an idea can be formed of the amount of power which could be developed on the stream, and at what points.(*a*) The heights of the dams, in the following description, are measured from the bed of the stream.

From the basin at Fredericksburg the canal extended nearly 2 miles to a lock with a lift of 11 feet, and beyond one-quarter of a mile, to dam No. 1, which was 7 feet high, and the feeder of the lower levels.(*b*) This dam is not the dam of the water-power company, but was nearly a mile above the latter, and is now washed away, the navigation works having been abandoned before the construction of the present dam. In the pool of this dam boats crossed to the left bank of the river, thence by canal 2 miles to a lock with a lift of 12 feet, and beyond one-quarter of a mile to dam No. 2 (Banks' dam), about 10 feet high. At the lift-lock just referred to there was at one time a grist-mill. Above Banks' dam there was slack-water navigation for 2½ miles, to a lock of 10 feet lift; thence one-quarter of a mile canal to dam No. 3 (Ballad's or Ballard's dam), about 10 feet high; thence slack-water, 2 miles, to a lock with 10 feet lift, and dam No. 4 (Smith's dam), 11 feet high; thence slack-water again 2 miles, to locks at United States mill (at Barrows' ford), 22 feet lift; then canal 1 mile to lift-lock of 9 feet lift, and 1 mile farther to dam No. 5 (United States dam), 6 feet high, just below the junction of the Rappahannock and Rapidan, above which was slack-water for 1½ mile to locks at Richards' ferry, 20 feet lift; thence canal one-half mile to dam No. 6 (Richards' dam), about 6 feet high. Before proceeding further, attention must be called to the large fall in this part of the river, as shown by the large amount of lockage. There seems to be no doubt that a considerable amount of power could be developed in this vicinity; and as the canal and locks, although in bad condition, are not entirely destroyed, it is possible that a good deal of power might be cheaply utilized. The

a For detailed information regarding the canal I am indebted to Wellington Gordon, esq., of San Francisco, California, who was president of the navigation company.

b The following is quoted from a report on the canal in one of the reports of the board of public works of Virginia: "Between Fox's mill [43 miles above Fredericksburg] and Fredericksburg the Rappahannock presents three passes of peculiar difficulty and danger. The first is near Fredericksburg, the second at the junction of the Rappahannock and the Rapidan, and the third in the vicinity of Kelly's and Wheatley's mills. The first is overcome by a dam 7 feet in height and a canal 2 miles in extent, carried for a considerable distance under a precipitous cliff, and terminating in a basin 26 feet above the level of the river at its nearest point. Between the dam and the basin are a guard-lock, a lift-lock of 11 feet, a second guard-gate, and 3 waste-weirs. In the second a fall of 35 feet is overcome by two dams, two canals—one of 800, the other of 900 yards in extent—and four locks. The third is under construction, but not completed."

drainage area of the Rappahannock above its junction with the Rapidan is about 784 square miles, and that of the latter stream about 745, the total below the junction being 1,529 or thereabout. I should estimate the flow and power for these three drainage areas about as follows:

State of flow (see pages 8 to 11).	Drainage area in square miles.			Flow, cubic feet per second.			Horse-power available, 1 foot fall, gross.		
	Rappahannock.	Rapidan.	Both.	Rappahannock.	Rapidan.	Both.	Rappahannock.	Rapidan.	Both.
Minimum	784	745	1,529	78	75	168	8.9	8.5	19.1
Minimum low season				102	98	220	11.8	11.2	25.0
Maximum with storage				693	658	1,350	78.8	74.8	153.6
Low season, dry years				117	112	250	13.3	12.7	28.4

Above dam No. 6 there was slack-water for half a mile to a lock with 12 feet lift; thence canal for 1½ mile to dam No. 7 (Deep Run dam), about 7 feet high; thence slack-water 1¾ mile to a lock with 12 feet lift and canal half a mile to dam No. 8 (Skinker's dam), about 5 feet high; thence slack-water to locks with a total lift of some 23 feet and canal for a quarter of a mile to dam No. 9 (Ellis' dam), about 8 feet high. Near this place is a grist- and flour-mill with 4 runs of stones, a race three-quarters of a mile long, into which the water is turned by a rough wing-dam, and a fall of 18 feet—no doubt an excellent power. Although it is the first power utilized above Fredericksburg, there have been in former times various mills in the intervening distance. Two miles below Ellis' mill there was at one time a mill (known as the Skinker mill) using a fall of some 20 feet, with a race a quarter of a mile long. The fall in this part of the river for a distance of 5 or 6 miles seems to be very great, and capable of giving a number of fine powers. The power per foot may be taken as estimated above in the table. Above dam No. 9 there was slack-water for 2 miles to a lock with a lift of 7 feet and dam No. 10 (Kemper's dam), about 9 feet high, the back-water from the dam below reaching up to this one. Then came slack-water for 2 miles to a lock of 8 feet lift and dam No. 11 (Mountain Run dam), about 10 feet high; thence slack-water for 2 miles to Kelly's mill and a flight of 5 locks, aggregating a lift of about 42 feet; thence canal half a mile to dam No. 12 (Wheatley's dam), about 7 feet high. The fall of the stream in the mile below this dam is very great and the site one of the best in the vicinity, so that it merits a more particular description. Wheatley's dam was about 2 miles below the present crossing of the Virginia Midland railroad and about 2½ miles from Rappahannock station. Wheatley's mill (now destroyed) was on the left bank, using the old canal as a race, and using a fall of about 23 feet. Below his tail-race, or about three-quarters of a mile by the river below his dam, was Kelly's dam, still in existence, from which a race of a quarter of a mile led to Kelly's mill on the right bank, still in use, with a fall of 19 feet, making the total fall about 42 feet. There would be no difficulty in utilizing the whole of this fall. The best building-ground is on the right bank, and by putting a dam about half a mile below the head of the shoal and making it 12 or 15 feet high a considerable pond could be obtained—sufficient, I think, to allow the power due to the natural flow to be increased 30 per cent. during twelve hours; while by using the power on the left bank the old canal could be cleaned out and used as a race. The bed of the stream is rock, gravel, and bowlders, the banks in places steep, but generally shelving, of clay or rock, and the width of the bed of the stream about 200 feet. Kelly's dam is a crib-work structure, rebuilt in 1867 or 1868, about 320 feet long and 3 or 4 feet high, not ponding the water over 100 yards. At the mill about 60 horse-power is used. The flow is stated to be much more variable than formerly, and in heavy freshets the river is said to rise 20 feet and more at the foot of the shoal and 10 feet at the head, although in ordinary freshets the rise at the foot is not over 8 or 10 feet. There is little trouble with ice. I have estimated the power at this place in the following table, the rainfall being about the same as above Fredericksburg:

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow, per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*23 feet fall.*	*42 feet fall.*
Minimum	614	42	61	6.9	160	290
Minimum low season			80	9.1	210	380
Maximum with storage			543	61.7	1,400	2,600
Low season, dry years			92	10.4	240	440

I have already alluded to the possibility of increasing this power in dry seasons by ponding the water during the night. This site is quite conveniently located as regards transportation; and good building-materials, it is said, can be obtained in the neighborhood.

From Wheatley's dam (No. 12) there was slack-water for 1½ or 2 miles, to dam No. 13 (Morgan's dam), about 7 feet high, and a lock with 6 feet lift. This dam is still in existenec, and is about 200 feet long, and 6 feet high, above low water, affording power to run a grist-mill with about 30 horse-power, just at the crossing of the Virginia Midland railroad. Above it was slack-water about 1 mile to dam No. 14 (Beverly's Ford dam), about 7 feet high,

with a lock of 6 feet lift; thence slack-water to lock and dam No. 15 (7 and 9 feet); thence slack-water a mile to a lock (7 feet); thence canal one-eighth of a mile to dam No. 16 (Lee's dam); thence slack-water 1½ mile to lock (9 feet); thence canal one-eighth of a mile to dam No. 17 (Fox's dam), about 9 feet high; thence slack-water to lock (7 feet), and dam No. 18 (Sulphur Spring dam), 8 feet high; thence slack-water 2 miles to locks with 16 feet lift, and beyond, canal for 1½ mile to dam No. 19 (Hart's dam), about 10 feet high, which was the last of the navigation dams. Above this point the river is very small. All the old dams referred to were founded on rock, which was generally found about 2 feet below the bed of the stream. The dams were of timber cribs filled with stone, and the abutments were in most cases either of natural rock or of masonry in cement, very substantially built. Notwithstanding the considerable length of slack-water navigation, it is said that very little land was flooded.

From what has been said, it is clear that the Rappahannock river offers a large amount of unimproved power. The conditions seem to be decidedly favorable for its development, the principal objections being the inaccessibility of the stream, and especially its very variable flow. But the fact that at most of the points where power could be used to the best advantage there is a canal already cut, in some cases needing little work to put it in repair, should counterbalance these objections to some extent.

Of the tributaries of the Rappahannock, the only one of importance is the Rapidan, which takes its rise in Greene and Madison counties, and flows rather north of east, forming the boundary between Orange and Spottsylvania counties on its right, and Madison and Culpeper on its left, and joining the Rappahannock 10 or 12 miles above Fredericksburg. Its total length, in a straight line, is about 40 or 45 miles, and its drainage area, as already mentioned, is 745 square miles. The stream resembles the Rappahannock in all essential particulars. Its elevation at the crossing of the Virginia Midland railroad is 278 feet, so that its fall is not much different from that of the Rappahannock, the distance from the junction to the railroad being probably a little greater in the case of the Rapidan.

The first power on the stream is one not utilized, near the mouth of Flat run. There was at one time a mill here with a fall of 8 feet, and some stamps were run in connection with a gold-mine in the vicinity, but at present there is nothing.

There are several other unimproved powers in this part of the stream, the next one above, which was specially mentioned, being known as "Germania", where there was a mill thirty-five years ago, with a fall of 6 or 7 feet. According to the map, this place is 10 or 12 miles above the mouth of the river.

At Raccoon Ford, perhaps 10 miles farther up, there is a grist-mill with a fall of 7 feet and about 25 horse-power, with a dam 300 feet long and 7 feet high. It is stated that full capacity can be secured during only eight or ten months, and that there is not much waste by leakage. The kind of motor is not known.

Next comes a grist-mill with a fall of 8 or 9 feet; and then, at Rapid Ann Station, a flour-mill using 50 horse-power and a fall of 9 feet, the dam being 240 feet long and 9 feet high. Full capacity can be obtained during nine months, with some leakage in summer. The drainage area above this place is about 440 square miles. Above are a number of small mills, and one site not used, known as Peyton's, with 6 or 7 feet fall, just above Rapid Ann Station.

The tributaries of the Rapidan and those of the Rappahannock afford small powers, and some of the streams are utilized to a considerable extent. None of the powers, however, are large.

Table of statistics of utilized power on the Rappahannock river and its tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	No. of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Rappahannock river	Chesapeake bay	Virginia	Spottsylvania	Woolen	1	18	45
Do	do	do	do	Flour and grist	3	75	220
Do	do	do	do	Fertilizers	1	18	50
Do	do	do	Stafford	Flour and grist	1	18	40
Do	do	do	Culpeper	do	1	16	40
Do	do	do	Fauquier	do	1	[illegible]	30
Do	do	do	Rappahannock	do	3	[illegible]	36
Do	do	do	do	Saw	1	25	12
Rapidan river	Rappahannock river	do	Orange	Flour and grist	2	16½	92
Do	do	do	Madison	do	2	34	20
Other tributaries of	do	do	Lancaster	do	4	43	57
Do	do	do	Middlesex	do	6	64	105
Do	do	do	do	Saw	3	39	40
Do	do	do	Richmond	do	1	....	18
Do	do	do	do	Flour and grist	5	64	136
Do	do	do	Essex	do	10	....	196
Do	do	do	do	Saw	1	12	20
Do	do	do	King George	Flour and grist	2	27	55
Do	do	do	Caroline	do	3	36	28
Do	do	do	Spottsylvania	do	2	35	24
Do	do	do	Orange	do	5	68	76

Table of statistics of utilized power on the Rappahannock river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	No. of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Rappahannock river	Virginia	Culpeper	Flour and grist	17	211	360
Do	do	do	do	Saw	2	25	22
Do	do	do	do	Furniture	1	14	10
Do	do	do	Fauquier	Flour and grist	3	60	85
Do	do	do	Rappahannock	do	16	240	217
Do	do	do	do	Saw	1	19	20
Do	do	do	do	Leather	1	18	15
Do	do	do	do	Wheelwrighting	1	10	15
Do	do	do	do	Woolen	1	16	15
Do	do	do	Madison	Flour and grist	11	144	149
Do	do	do	do	Saw	4	40	58
Do	do	do	do	Woolen	1	6	15
Do	do	do	Greene	Flour and grist	3	44	48
Do	do	do	do	Leather	1	9½	2

IV.—THE POTOMAC RIVER AND TRIBUTARIES.

THE POTOMAC RIVER.

The Potomac river is formed by the union of its two branches, the North branch and the South branch, on the line between Hampshire county, West Virginia, and Alleghany county, Maryland, whence it pursues a course at first north of east and then southeast, forming for its entire length the boundary between the state of Maryland and the states of West Virginia and Virginia, and emptying into Chesapeake bay about 60 or 70 miles from cape Charles. It drains a total area of about 14,500 square miles, but its course is so devious that some of its head-waters are not over 180 or 190 miles from its mouth, measured in a straight line. The principal streams tributary to the river are the following, in their order, beginning at the mouth:

Drainage areas.—Tributaries of the Potomac river.

	Square miles.
From the north:	
Seneca creek	163
Monocacy river	1,010
Antietam river	343
Conococheague creek	493
Licking creek	185
Conetowarts creek	165
Sideling creek	121
Town creek	190
North branch	1,316
From the south:	
Occoquan creek	573
Goose creek	466
Shenandoah river	2,850
Opequan creek	286
Buck creek	220
Sleepy creek	214
Great Cacapon creek	616
Little Cacapon creek	163
South branch	1,580

The two branches which form the river rise in the Alleghanies, the North branch near the western corner of the state of Maryland, and the South branch in Virginia and West Virginia, near the sources of the Cowpasture and Jackson's rivers (the head-waters of the James), whence it flows nearly north. These branches, with their affluents, and the tributaries of the main stream as far down as the Shenandoah, drain a series of narrow and generally fertile valleys lying between the parallel ranges which make up the system of the Alleghanies in this region. Their falls are, as a rule, not very large, their declivities uniform, and their beds gravel and sand. Their chief peculiarity lies in the great fluctuations to which their flow is liable. The rain falling on the mountains is shed rapidly into the water-courses by the steep side slopes leading to the narrow valleys below, and there being few lowlands to overflow, and so to store the freshet water, and no lakes whatever in the region, these streams, and with them the Potomac river, are subject to very sudden and heavy freshets, while in dry seasons their discharge

becomes very small. A glance at the table on page 9 of the present report, which contains the results of all the gaugings on the Potomac which could be obtained, shows this peculiarity very plainly. The flow of the North branch at Cumberland, when at its minimum, is found to be only one-tenth as large in proportion to its drainage area as would be expected from a stream of similar size in New England; and the minimum flow of the Potomac at the Great falls is seen to be exceedingly small for so large a stream. This characteristic seems to be more marked in the case of the tributaries from the south than in the case of those from the north, in which direction the country opens out somewhat, the mountains diminish in height, and the width of the valleys becomes rather greater.

From the junction of its two branches the Potomac cuts through the mountains nearly at right angles. Its valley in this part of its course is narrow, its fall at places quite rapid, the bed generally gravel, bowlders, and sand, with rock at a small depth, and often at the surface, and the banks generally high and sometimes precipitous, with not many low grounds subject to overflow. After receiving the Shenandoah at Harper's Ferry, the stream cuts through a narrow gap in the Blue ridge and reaches the true Atlantic plain. It crosses the fall-line a few miles above Washington, and reaches tide-water at Georgetown. From this point to its mouth it is sluggish, tidal, and navigable, there being at present a navigable depth up to Georgetown, 105 miles from its mouth, of 16 feet at low tide and 19 feet at high tide. Above Georgetown there are various shoals which prevent further navigation.

The rainfall in the valley varies from 44 inches in the lower part to 38 inches in the upper part. Regarding its amount and distribution above various points, it will be seen by the table on page 9, that, as in the case of the Rappahannock and the James, the distribution through the seasons is very irregular, there being a small fall in autumn and winter. The effect of this will be seen in a small minimum and low-season flow, occurring probably late in the autumn; and this fact goes far toward explaining the very small measured values of the minimum flow.

The declivity of the stream is shown by the following table:

Slope of the Potomac river.

Locality.	Distance from tide.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Georgetown	0	0			
			61.5	245	4.0
Harper's Ferry	61½	245			
			9.5	35	3.7
Shepherdstown	71	280			
			14.0	39	2.8
Dam No. 4	85	319			
			22.0	38	1.7
Dam No. 5	107	357			
			78.0	253	3.2
Cumberland	185	610			

NOTE.—Distances are in some cases inaccurate.

It will be noticed that the elevation of the Potomac when it passes through the Blue ridge is about 245 feet, while that of the James at its passage through the same range of mountains (at Blue Ridge dam, see page 14) is 706 feet. The fall of the Potomac is therefore much smaller than that of the James, though still quite large. Of the 245 feet below Harper's Ferry about 90 occur in a short distance at the Great falls; and if this be subtracted, the fall in the remaining distance is found to average about 2.5 feet per mile.

As a water-power stream the principal disadvantage of the Potomac is the great variability of its flow. In all other respects it seems favorable. Good rock foundations for dams can generally be obtained at small depth, the banks are as a rule favorable, and there are several sites where large falls could be rendered available, as will be seen hereafter. Building-materials can generally be found, and the facilities for transportation are excellent. The map shows that the Baltimore and Ohio railroad follows the river for its entire length, receding at places several miles from it, but for long distances keeping within sight of it. In addition to this, the Shenandoah Valley railroad and the Cumberland Valley railroad cross the stream. Finally, the Chesapeake and Ohio canal follows it almost within sight at every point, from Georgetown to Cumberland, on the North fork, using it in a few places for slack-water navigation. The ponds are not large, and the facilities for storage on the main stream are very small. On some of the tributaries sites for small reservoirs could be found, while on many there are no facilities.

Aside from a small amount of power which is used from the Chesapeake and Ohio canal, there is only one mill using power from the river—a very remarkable fact, considering that there are several large falls.

Water is leased by the canal company—to be discharged either around the locks into lower levels or into the river—generally by the square inch of opening; "opening to be placed with its lower edge 2 feet above canal bottom, and to be cut square through an iron plate half an inch thick". No head or quantity of water is guaranteed, as the canal is to be used primarily for navigation. The original rates for water were $2 50 per square inch per annum, leased for twenty years, a bonus of $3 per inch payable upon every renewal. The experience in regard to leasing

water has been that it is not advisable to lease large quantities, that it is a source of inconvenience to navigation, and does not pay. The velocity allowed on the canal is considered to be about 1½ mile per hour, or 2.2 feet per second, or rather larger than on the James River and Kanawha canal. Loaded boats coming down get the benefit of the current, and the greater part of the traffic is down the river; moreover, the dimensions of the canal are rather greater than those of the James River canal, so that a larger velocity would be required here to offer the same resistance to boats. Considerable power could be rendered available above Georgetown by using the flume-water at the locks, or the water which passes around the locks to supply the levels below; but the amount of power which might thus be rendered available can not be estimated, varying at different places and according to the weather, the traffic, etc. As the company does not guarantee any special head or quantity of water, the mills on the canal have to regulate their work according to the navigation in the canal. Those above Georgetown can, however, get their full capacity as long as there is water in the canal, but the water is entirely drawn off during the months of December, January, and February. The mills on the Georgetown level run nearly all the year, subject only to occasional short interruptions; and the water is drawn off from this level for ten days in the year for ordinary repairs. None of the mills use auxiliary steam-power, however.

The canal is fed entirely from the Potomac and the North branch, and there are no artificial reservoirs connected with it except the ponds of the dams on the river, of which there are eight between Georgetown and Cumberland. At some of these dams power could be used, as will be seen hereafter, but the ponds are all so small that they afford no great storage-room. The original dimensions of the canal were as follows: From Georgetown to Harper's Ferry, 60 feet wide at top, 42 at bottom, 6 feet deep; from Harper's Ferry to dam No. 5 the corresponding dimensions being 50 feet, 32 feet, and 6 feet; and from dam No. 5 to Cumberland, 54 feet, 30 feet, and 6 feet.

The following table gives the mills and power supplied from the canal:

Name of place.	Kind of mill.	Number of square inches.	Head.	Quantity of water per second.	Head and fall.	Horse-power, gross.	Remarks.
			Feet.	*Cubic feet.*	*Feet.*		
Georgetown	Paper	417	*a*4		34.5		Head and fall of 34.5 feet to mean high tide; discharge to river.
Do	Corn	328	*a*4		34.5		
Do	Fertilizers	229	*a*4		34.5		
Do	Flour	2,595	*a*4		34.5		
Do	Not used	731	*a*4		34.5		
Total in Georgetown		4,300	*a*4	310±	34.5	1,214±	
Berlin, Frederick county	Flour and fertilizers			(Estimated) 55	6	37	Flume-water of one lock.
Weverton	Flour				17	25–30	Waste water leased; discharged to river.
Above Antietam aqueduct	Saw	50		Small	8–10		Discharged to river.
Williamsport lock	Saw				8		Flume-water.
Williamsport aqueduct					28		Discharged to river.
Above dam No. 5		33	2	Small			Discharged to river.
Hancock	Grist	200	4		24±		
Above Hancock	Cement	500±	3–4		24±		

a Or less.

NOTE.—For my information regarding the canal and the power used from it, as well as for much valuable information regarding the flow of the river, etc., I am indebted to Mr. William R. Hutton, civil engineer, now of New York, consulting engineer of the canal company.

The power supplied is therefore very small in amount, though it might be increased greatly. In view of the fact that the amount available depends entirely upon the state of traffic on the canal, and other circumstances, estimates can not be made and are not necessary. The amount of water necessary for the purposes of navigation is very variable, and in dry seasons the flow at Cumberland is not sufficient to supply these wants, so that the height of the water in the levels below gradually sinks, from evaporation and leakage, and at Patterson's creek a steam-pump raises 100,000 or 120,000 gallons per minute to supply the canal. In the above table "waste water" means the surplus which comes down to a given level over what is required for lockage, etc., below, and which is therefore returned to the river.

Ascending the river itself, the first power is about 5 miles above Georgetown, at Little falls, where canal dam No. 1 supplies the Georgetown level. The dam is 1,750 feet long, 7 feet high above low water, and is built of riprap. Its crest is about 37 feet above tide. The river is shoaly for some distance below, and it is probable that a fall of 10 feet or more could be used here. The dam, however, is not tight, so that at present, as already stated, the canal company can not always supply their present leases on the Georgetown level; but with a close dam a large amount of power could be used, either near the dam or below at various places on the level. If the allowable velocity on the canal be taken at 2.2 feet per second, the canal could carry about 670 cubic feet per second, which would afford at Georgetown, with a fall to mean high tide of say 30 feet, a gross power of nearly 2,300 horse-power. The following table contains estimates of the flow of the river, from which an idea of the power at the dam itself can be formed:

Estimate of flow and power at Little falls.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.		*Cubic feet.*	*1 foot fall.*	*10 feet fall.*
Minimum	11,588	Height of dam, 7 feet; available fall, probably about 10 feet.	1,075	122.0	1,220
Minimum low season			1,970	223.8	2,240
Maximum with storage			10,300	1,170.0	11,700
Low season, dry years			2,300	261.3	2,600

The pond of the dam is not used for navigation, and the facilities for building are good just below the dam.

The next site above is at the Great falls of the Potomac, 14 miles above Georgetown. The water pours here over a solid mass of rock, with banks of the same material, often very steep and precipitous just at the edge of the water, but with level or nearly level places on top of the bluffs, extending back in some places a hundred yards or more, the facilities for building being ample on both sides of the river. The stream descends at the principal fall perhaps 35 or 40 feet in 100 or 150 yards, and the total fall in a distance of about a mile or a mile and a half is 80 or 90 feet. The stream is narrow for the greater part of this distance, and in freshets the water is said to rise 30 or 40 feet at some points. It is said that many years ago a canal 1½ mile long was built around the falls on the Virginia side, which, in the event of the development of the power, could be used as a race, though it is now almost entirely filled up.

The drainage area above the Great falls is about 11,476 square miles, and the rainfall is given in the table on page 9. The stream has been gauged at this point, and the minimum flow found to be 1,069 cubic feet per second. The ordinary low-water flow, however, is stated at over 2,000 cubic feet per second. I have estimated the power as follows:

Estimate of flow and power at the Great falls of the Potomac.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*80 feet fall.*
Minimum	11,476	80–90	1,069	121.5	9,720
Minimum low season			1,950	221.6	17,730
Maximum with storage			10,213	1,160.5	92,840
Low season, dry years			2,300	261.3	20,900

No power is used at this site. The water for supplying the cities of Washington and Georgetown is drawn from the river just above the falls and conducted to its destination through a large aqueduct; but the quantity of water taken is very small compared with the flow of the stream. One disadvantage of the site is that it is not easily accessible except by the canal. The latter, however, affords good advantages for transportation.

The next site is at canal dam No. 2, at the mouth of Seneca creek. The dam is 2,500 feet long, and from 2 to 10 feet high from the rock foundation, and is a rubble dam and frequently damaged by floods. Its crest is about 180 feet above tide. The site is not a very favorable one, the fall being small and the facilities for building not very good. Not knowing the fall, estimates of the power would be of little value.

The next site is where the river breaks through the Blue ridge, just below Harper's Ferry. From Weverton, 3 miles below Harper's Ferry, to dam No. 3, a mile above that place, the fall is almost continuous, forming really but one shoal or rapid; but as the part above the ferry could best be used at or above the town, it is best to consider the shoal in two parts. From Harper's Ferry the stream falls 25 feet in a distance of 3 miles,(*a*) the bed being rocky, and the banks, though in places steep, as a rule, favorable for a dam, and with numerous sites for building. It was at one time attempted to develop this power, and in 1834 the Weverton Manufacturing Company was incorporated with this object in view. The site was surveyed by E. N. Dickerson, of Paterson, New Jersey, who reported on the property in glowing terms, and subsequently a dam was built and a cotton-mill and some other mills started; afterward a file factory was put up, together with a large flour-mill on the other side of the river; but for some reason none of them continued long in operation, and at present the site is altogether unimproved. The available power is estimated in the annexed table:

Estimate of flow and power of the Potomac river at Weverton.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*25 feet fall.*
Minimum	9,260	*b* 25	860	97.7	2,440
Minimum low season			1,570	178.4	4,460
Maximum with storage			8,240	936.3	23,400
Low season, dry years			1,800	204.5	5,100

a E. N. Dickerson's report, 1845.

b Dickerson states the total available fall at 45 feet, including, no doubt, a large part of the fall above Harper's Ferry.

On account of the rapid fall of the stream above, the pond would be small unless the dam were very high. It is stated that fine building-materials abound in the immediate vicinity; and as far as transportation is concerned the advantages are excellent, the canal and the railroad passing directly by the place. As regards facilities for dams and races there would also be no difficulty, except perhaps that the freshets might cause a stoppage of work at intervals.

At Harper's Ferry, where the Shenandoah joins the Potomac, the latter stream passes through a deep and rocky gorge with almost perpendicular banks for a short distance. Above that point the fall of the river is rapid, and about 1½ mile above we come to dam No. 3, which was originally built, it is said, to supply power to the government works at Harper's Ferry; but those works were destroyed during the war and have not been in operation since, and the dam, being now used only as a feeder to the canal, is not in good order. It was formerly built of low cribs, but is now partly riprap and partly dry wall 2 to 5 feet high above the rock. The fall of the river from the dam down to the mouth of the Shenandoah is about 27 feet. On the north side of the river the canal skirts the bank so closely that no room remains for the utilization of power; but on the south side, where the government factory was located, the facilities for canals and buildings are tolerably good, though rather limited as regards space. The old canal, leading from the dam to the factory, is now dry and partially filled up. It is said that a fall of about 22 feet was formerly used at this place, and it is probable that no more than this could be utilized without raising the dam, the building-sites being located about an eighth to a quarter of a mile above the mouth of the Shenandoah. At present no power whatever is used here. The following table contains estimates of the power available:

Estimate of flow and power of the Potomac river at Harper's Ferry.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	22 *feet fall.*
Minimum	6, 380	22 ±	575	65. 3	1, 430
Minimum low season			1, 020	115. 9	2, 550
Maximum with storage			5, 740	652. 0	14, 350
Low season, dry years			1, 166	132. 5	2, 900

The freshets in the river are felt quite severely at this point, and it is said that at one time the river rose 25 feet above low water. Ice-jams, however, rarely occur. The facilities for transportation are excellent, building-materials are abundant, and there seems to be no reason why a large and fine power could not be utilized here. The site is probably the most favorable one on the river.

The next site is about a mile below Shepherdstown, and about 10 or 12 miles above Harper's Ferry. At this place there is a wooden dam about 600 feet long and 8 feet high, which supplies power to a cement-mill on the right bank, the fall used being 8 feet and the power 30 to 50 horse-power. The race is 500 feet long and 60 feet wide, and the dam is said to pond the water for several miles. This mill is the only one supplied directly from the Potomac river. The available power is estimated in the table on the following page.

The next site is at dam No. 4, about 25 miles above Harper's Ferry. The dam is of masonry, 800 feet long and 15½ feet high above low water (20½ feet from rock foundation). Along the canal, on the Maryland side, the tow-path is too narrow and too low to allow of any mills being located there, but on the Virginia side there are sites for building. The estimates of available power are given with sufficient detail on page 45. The pool of this dam is used for navigation for a distance of 3½ miles.

We next come to dam No. 5, about 7 miles above Williamsport. It is 720 feet long and 16½ feet high above low water (20½ to 24 feet from rock foundation), and is built of masonry. Before the war a large flour-mill—the Honeywood mill—used water on the Virginia side, and there is no favorable site for others on that side; but on the Maryland shore the canal-bank could be used for some distance, though in many places the tow-path is built up from the river, leaving no sites for buildings. The pool of the dam is used for navigation for half a mile. The power is estimated below.

Dam No. 6, 10 miles above Hancock, is a crib-work dam filled with stone, and is 470 feet long and 15½ feet high above low water (20½ feet above rock foundation). Its crest is about 428 feet above tide. There are some sites on the Virginia side, and on the Maryland side the whole length of the canal could be used.

Dam No. 7 was never built. The stream has considerable fall in this part of its course, and power could probably be developed at many places, but it might be difficult to find convenient locations, as the railroad on one side and the canal on the other often occupy all the ground which would be available for building. The only sites on the river which seem to be of great importance are those at the Great falls, at Weverton, at Harper's Ferry, and at the other canal dams. For reasons already stated, estimates are not given of the amount of power which could be obtained from the canal, although there are many places where power could conveniently be used in that way, as, for instance, below dam No. 6.

Dam No. 8, being on the North branch, at Cumberland, will be considered when that stream is described.

Summary of estimates of flow and power of the Potomac river.

Name of place.	Distance from Georgetown.	Drainage area.	Rainfall. Spring.	Rainfall. Summer.	Rainfall. Autumn.	Rainfall. Winter.	Rainfall. Year.	Total fall. Length.	Total fall. Height.	Horse-power available, gross. (a) Minimum.	Horse-power available, gross. (a) Minimum low season.	Horse-power available, gross. (a) Maximum with storage.	Horse-power available, gross. (a) Low season, dry years	Utilized. Fall.	Utilized. Horse-power, net.	Remarks.
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Miles.*	*Feet.*					*Ft.*		
Dam No. 1 (Little falls)	5	11,588	11	12	9	8	40	......	10	1,220	2,240	11,700	2,600	...	....	Dam 7 feet high. Power utilized below, at Georgetown.
Great falls	14	11,476	11	12	9	8	40	1½	80–90	9,720	17,730	92,840	20,900	...	....	
Dam No. 2	....	11,389	11	12	9	8	40	......	Small.	....	....	....	....	...	....	
Weverton	57	9,260	11	12	9	8	40	3	25	2,440	4,460	23,400	5,100	...	....	
Harper's Ferry	60	6,380	11	12	9	8	40	1½	22±	1,430	2,550	14,350	2,900	...	....	
Shepherdstown	70±	5,975	11	12	9	8	40	......	8	480	800	4,880	920	8	30–50	Dam 8 feet high.
Dam No. 4	85	5,899	11	12	9	8	40	......	15½	775	1,500	9,300	1,725	...	....	Dam 15½ feet high.
Dam No. 5	106	5,066	11	12	9	8	40	......	16½	700	1,420	8,550	1,625	...	....	Dam 16½ feet high.
Dam No. 6	136±	3,550	11	12	9	8	40	......	15½	440	875	5,600	1,000	...	....	Dam 15½ feet high.

a See pages 8 to 11.

TRIBUTARIES OF THE POTOMAC RIVER.

The first tributary whose water-power is worth mentioning is Occoquan creek, which is formed by the union of Broad run and Cedar run, in Prince William county, Virginia, whence it pursues an easterly course for a distance of about 13 miles in a straight line, and after forming for some distance the boundary line between Prince William and Fairfax counties empties into the Potomac river about 25 miles below Washington. Broad and Cedar runs have their sources in Fauquier and Prince William counties, the former draining 87 square miles, and the latter rather less. The Occoquan receives as its principal tributary below these two, Bull run, which rises at the extreme northern corner of Prince William county, and forms for its entire length the boundary between that county and Fairfax, draining about 212 square miles. All of these streams flow through a hilly or rolling country, and have gradual declivities, with beds of gravel and sand, and they offer little power. The Occoquan, however, crosses the fall-line just before it reaches the town of Occoquan, which is the head of tide-water, and up to which there is a navigable depth of 5 feet at low tide and 7 feet at high tide. The fall begins about 3 miles above the head of tide-water, and continues down to tide, the stream falling about 80 feet in that distance "through bold and extensive masses of gneiss rock".(*a*) The banks are quite abrupt and very rocky for a mile above the head of tide-water, but above that they are in places more favorable for canals and buildings. Some power at the lower part of the shoal is used by a flour- and saw-mill at Occoquan, supplied by a race half a mile long, 10 to 15 feet wide, and 2 feet deep, one bank of which is a solid stone wall for a considerable distance, built up in some places to a height of 20 or 30 feet. At its head is a rough dam, very leaky, and built partly of brush and partly of stone in cement—the latter being tight. The mill has an available fall of 32 feet, but uses only 23, the remaining 9 feet having been at one time used by a cotton factory, discharging its tail-water to the present mill. The power used is perhaps 50 horse-power, but on account of the leakage of the dam, and interruption during about a month in winter on account of ice, this can be obtained during only ten months. By building a tight dam the entire flow of the stream could be used at Occoquan, with a fall of 32 feet, and by raising the dam a still greater fall could be rendered available. It would be possible to develop power above the dam, but it would be expensive compared with the power to be obtained. About 1½ mile above the dam a second one could be built, there being apparently a good site, where a high dam could be built without damaging land by backwater. In this way a fall of 14 or 15 feet could be used, and, by carrying a race farther down stream, a much greater fall, but it is not probable that much storage-room could be obtained. The total drainage area above tide-water being about 573 square miles, I have endeavored to estimate the available power in the following table:

Estimate of flow and power of the Occoquan river at Occoquan.

[NOTE.—Rainfall, about 42 inches—12 in spring, 13 in summer, 9 in autumn, 8 in winter.]

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross. 1 foot fall.	Horse-power available, gross. 23 feet fall.	Horse-power available, gross. 32 feet fall.	Horse-power available, gross. 80 feet fall.
	Sq. miles.	*Feet.*	*Cubic feet.*				
Minimum	570	80	57	6.5	150	210	520
Minimum low season			74	8.4	190	270	670
Maximum with storage			510	58.3	1,340	1,860	4,660
Low season, dry years			85	9.6	220	300	770

a Report of Board of Public Works of Virginia.

As regards transportation by sea, this place—at least the lower part of the falls—is very conveniently located, as boats can load directly from the mill. The town is 2 miles from the Alexandria and Fredericksburg railroad.

For the next 20 miles of its course the Occoquan has an average fall of 3.39 feet per mile, according to an old survey, and there are no powers worth naming. Bull run and Broad run furnish a few small powers, but none of much importance. On the latter stream there is quite a fall at Thoroughfare gap, where a mill uses a fall of 27 feet, but the power is only 20 or 30 horse-power. It is stated that in a distance of a mile at this place there is a fall of 150 feet. Four miles below there is a woolen-mill, not now in operation.

Some of the other small tributaries of the Potomac in this neighborhood cross the fall-line, giving rise to quite large falls but affording only very small powers; and in the neighborhood of Alexandria there are several such streams running small grist-mills; but there are really no other tributaries from the south side worth mentioning, east of the Shenandoah. Goose creek, Broad run, and Kittocton creek all supply small grist-mills with from 1 to 4 pairs of stones, and falls averaging 10 feet or thereabout. But these streams, as well as those from the north in this vicinity, are not of much value for water-power, on account of their running so very low in summer. They are, moreover, as a rule, sluggish, afford small facilities for storage without overflowing valuable lands, and are subject to heavy freshets.

The only stream from the north worth mentioning, east of the Blue ridge, is the Monocacy river, which has its sources in Adams county, Pennsylvania, and flows nearly south, entering the Potomac at the southeast corner of Frederick county, Maryland, and draining an area of about 1,010 square miles. It flows through a hilly and rolling country, is as a rule sluggish, and offers little power. The bed is gravel and sand, and there are no falls of note. Its flow, although not so variable as that of the tributaries farther west, is still liable to considerable fluctuations, and the freshets are sometimes of violence, the water rising 10 or 15 feet in places. The stream is used at several places to run flour-mills, but there are only two mills where the power is large enough to be mentioned specially. The first is about 12 miles below Frederick, at Greenfield Mills, where a fall of 7 feet is used and about 108 horse-power. The dam is of wood, 450 feet long and 5½ feet high, backing the water about 1½ mile, and was originally built in 1850, at a cost of $4,200. The head-race is 100 yards long. Full capacity can always be obtained, and there is always a waste of water. The drainage area above this place is about 1,000 square miles. The next power is about 6 miles above, near Buckeystown, where a fall of 7 or 8 feet is used, with about 75 horse-power, the dam being 6 or 7 feet high. The drainage area above is about 935 square miles. Above this there are small mills with falls of from 5 to 8 feet, and there are said to be no good sites not used. It seems to be evident that the power of the stream is of not much importance.

Some of the tributaries of the Monocacy seem to have a greater fall and to be more favorable for power than the main stream. Bennett's creek, though not a rapid stream, runs several small grist- and saw-mills. Bush creek is similar in character, but both of these streams run very low in summer, and some of the mills use steam part of the time. Linganore creek, draining 77 square miles, has more fall than those thus far mentioned, and has one mill with a fall of 15 feet and running six pairs of stones. Full capacity can be secured during only six months, the average during the rest of the time being about one-half. The drainage area of the Monocacy above the mouth of the Linganore measures about 800 square miles. Double Pipe creek, the largest tributary of the Monocacy, drains 264 square miles, and is formed by the union of Big Pipe creek and Little Pipe creek, which drain respectively 170 and 91 square miles. Although a very short stream, Double Pipe creek has one good mill with a fall of 9 feet and about 4 pairs of stones, the dam being 8½ feet high; and on the head-waters of the stream are many small grist- and saw-mills. Although mills might be located at some points by damming, the general testimony is that there are no sites worth mentioning on the Monocacy or any of its tributaries.

The next tributary of the Potomac, and the most important one of all, is the Shenandoah river, which joins it just as it passes through the Blue ridge, at Harper's Ferry, West Virginia. The Shenandoah has its head-waters in Augusta and Rockingham counties, Virginia, and pursues a general northeasterly course, draining the northern part of the great Virginia valley included between the Blue ridge on the east and the main chain of the Alleghanies on the west. The main stream is formed by the union of the North and South forks, which unite near the town of Front Royal, in Warren county, Virginia, whence the stream flows through Clarke county, Virginia, and Jefferson county, West Virginia, the length of its course, which is very tortuous, being about 54 miles (38½ in a straight line), and the total area drained 2,850 square miles. Of the two forks, the South fork is formed by the junction (at Port Republic, Rockingham county) of the South and Middle rivers—which above their junction are mere mountain streams—whence it pursues a very tortuous course through Page and Warren counties, between the Blue ridge and the Massanutten mountain, the length of its course being nearly 96 miles (52¼ in a straight line), and its drainage area 1,535 square miles; while the North fork has its head-waters in the northern part of Rockingham county, and flows through Shenandoah and Warren counties, between the Massanutten mountain on the east and North mountain on the west, its course being also very tortuous, and its drainage area 925 square miles.

The river is to a certain extent navigable, and works have at various times been executed for improving it. Early in this century some locks and canals were built on the lower part of the stream—below Little's falls, which are 6 or 7 miles above Harper's Ferry—while above that point the more important rapids and ledges were passed by means of sluices. Surveys of the river have been made at various times in the interest of navigation, all of

which are collected in the report of Colonel William P. Craighill, in the *Annual Report of the Chief of Engineers* for 1880, page 661, to which I am indebted for a great part of the following information regarding the stream.

The following extract from the report of Mr. N. H. Hutton, civil engineer, will serve to give an idea of the character of the main stream and the South fork. That of the North fork may be presumed to be similar:

The whole water-way from Port Republic to Harper's Ferry, excepting the lower 6½ miles, flows between alluvial banks, from 10 to 25 feet above low water, and has on either side, except for short distances and at wide intervals, areas of bottom-land from a few hundred feet in width to several thousands of feet; the spurs from the adjacent mountains rarely impinge directly on the water-way, and only for short distances. The lower section, however, extending from the head of Little's falls (6½ miles) to the mouth, is entirely unlike the upper portions, as here the mountains shut closely in on either bank, the bottom-land disappears, and the river descends over a succession of slate ledges with more than double the average fall per mile of its whole length.

As is usual with mountain streams, the river flows alternately through pools of comparatively slack water, and over ledges and shoals forming rapids and falls. As is also usually found in such cases, the pools are shorter and the ledges more numerous on the upper reaches than on the lower; on the upper 40 miles of the stream the pools rarely if ever exceed a mile in length, with from 2 to 4 feet depth of water, while on the remainder of the stream (to the head of Little's falls) they frequently attain a length of 3 or 4 miles with depths of from 4 to 7 feet of water. The depths over the ledges and shoals vary from 4 or 5 inches to 8 or 9 in their lowest places, as they generally, for considerable portions of their length, are above the plane of low water.

The South branch commences with a width of about 170 feet, and, with many irregular contractions and expansions between 150 and 250 feet, gradually increases to a width of about 350 feet at its junction with the other branch; the main stream thence gradually widens to 500 or 600 feet at its junction with the Potomac.

The whole fall, from Port Republic to Harper's Ferry, as given by Mr. Herron, is 793 feet, or about 5.4 feet per mile. This slope, however, is not equally distributed throughout the whole distance.

From Port Republic to Ammon's dam (7 miles) the river descends 50 feet, or over 7 feet per mile; thence to the forks at Front Royal (if we except a fall of 17 feet in 5,000 feet at Kemper's) the stream has for 86 miles an average fall of 6 feet per mile. From the forks to the head of Little's falls the slope averages, for 45½ miles, only 2⅔ feet per mile, while from the latter point to the mouth it falls nearly 12½ feet per mile. It will thus be seen that the third section counting from above, or that extending from Front Royal to the head of Little's falls, is the only one on which open-river up-stream navigation would be practicable if the slope were made uniform throughout.

Both the South branch and the main stream below are traversed by numerous ledges of slate and limestone, the latter predominating on the upper 40 miles of South branch and the slate below that point; the stream is also, more especially in the upper 25 miles, obstructed by shoals formed by loose rock or bowlders brought down by the freshets.

The whole number of ledges noted above Little's falls was about 700, and the total length of the bowlder and gravel shoals in the same distance was estimated at about 17,000 feet. Between the head and Mallon's iron-works (22 miles) the ledges average 9 per mile, and the bowlder and gravel bars aggregated 10,000 feet, or over 450 feet per mile; between the iron-works and Front Royal (junction of North branch) the ledges averaged 5 per mile, and below that to head of Little's falls they averaged a little over 3 per mile; the bowlder and gravel shoals on both sections averaging about 56 linear feet per mile. Below Little's falls the river is almost one continuous succession of ledges, over which navigation has never been attempted except by the aid of the locks, sluices, and canal of the Shenandoah Navigation Company. Aside from this lower reach, none of the ledges form falls of any magnitude, except at Kemper's falls, where the river runs close under the mountain cliffs, and falls 17 feet in 5,000 feet over a succession of limestone ledges.

As might be expected from its narrow, steep, and rocky water-shed, the river is said to be subject to frequent and rapidly-rising freshets. No exact data were attainable as to their usual and ordinary heights, but they do not seem to have generally exceeded 7 to 12 feet above low water except on such extraordinary occasions as that of the autumn of 1870 and 1877, when it rose from 25 to 30 feet in a few hours. Their effects can not generally, however, be very severe on the river bed and banks along the upper portions, for the general configuration of the river and the extent and shape of low points and islands were nearly the same during this reconnaissance as were indicated in the topographical notes of Mr. Herron's survey in 1832.

The absence of lakes in the drainage basin increases the violence of the floods, and were the fall of the stream not so large the water would rise to much greater heights. It is said, however, to have risen over 40 feet at the junction of the North and South forks in the freshet of 1870. Ice-jams are said to occur sometimes, but they are of course not so dangerous as on the streams farther north. The rainfall over the basin averages about 40 inches—12 in spring, 12 in summer, 8 in autumn, and 8 in winter. The gauging in the table on page 9 is given by Mr. Herron.(*a*)

The elevations above tide of some points on the stream are given in the following table:

Slope of the Shenandoah river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Harper's Ferry, junction with Potomac	0.0	242	2.5	44	17.6
Bull's falls	2.5	286	5.5	40	7.3
Near mouth of Evitt's creek	8.0	326	10.0	34	3.4
Castleman's ferry	18.0	360	13.0	40	3.1
Berry's ferry	31.0	400	23.0	53	2.3
Confluence of North and South forks (*b*)	54.0	453	96.0	586	6.1
South fork, near Port Republic	150.0	1,039			

a Seventeenth Report of the Board of Public Works of Virginia. *b* Profiles of the Shenandoah Valley railroad give this elevation as 445 feet.

Until recently the main stream and the South branch have not been very accessible, except for a few miles above Harper's Ferry, being removed on the average about 10 or 12 miles from the Baltimore and Ohio railroad (Valley branch), which follows the North branch. By the construction of the Shenandoah Valley railroad, however, almost every point of the stream is brought within easy reach.

The large fall of the river is sufficient evidence that it affords a very large amount of power theoretically available. Very little, however, is utilized, as the table on pages 52 to 54 will show. With a few exceptions, which will be indicated, the rapids and falls referred to in the extract from Mr. Hutton's report, though numerous, have but small fall; so that, although mills might be located at many of them, the falls available would be small (probably not over 5 to 8 feet, as a rule), and it would generally be necessary to build dams. At a number of these sites mills were located 15 or 20 years ago; but the freshets of 1870 and 1877 proved so destructive, and carried away so many dams, that people have been deterred from utilizing power on the river in later years. The old dams, however, were generally built of logs and brush, and were for the most part leaky and unsubstantial; and considering the good foundation which can generally be obtained, there seems to be no reason why there should be difficulty in building dams strong enough to withstand any freshet to which they might be subjected.

The following are the principal powers met with as the river is ascended:

The principal fall on the stream occurs in the lower 8 miles of its course, according to the above table. This fall was overcome by the navigation company by means of a series of locks, canals, and sluices, which are described by Mr. Hutton as follows:

For a great many years anterior to the civil war, a system of down-stream navigation, per flat-boats, was maintained throughout the main stream and South branch, the works above Little's falls consisting of low wing-dams and sluices, and, below that, of a system of locks and canal combined with sluices and open-river navigation. No attempt appears ever to have been made to establish an up-stream navigation, unless possibly on the lower reach, where remains of a towing-path still exist; though, with a fall in the water-way, outside the locks, of nearly 7 feet per mile, it may well have been called an uphill business.

The navigation works between the head of Little's falls and the mouth of the river, commencing at the head of Little's falls, consisted of: 1. A lock of 6 feet lift; 2. A sluice 2,000 feet long, falling 5 feet; 3. Open river for 4,000 feet, falling 8 feet; 4. A sluice and mill-race 1,800 feet long, falling 1 foot; 5. A lock of 10 feet lift; 6. Open river for 3¾ miles, falling 15 feet to the foot of Bull's falls; 7. A canal behind Virginius island, 9,200 feet long and about 30 feet wide, with a single lock of 5 feet lift and a double lock of 15 feet lift, leaving 16 feet of fall to be passed over outside of the locks.

All traces of the works above this section have disappeared, and the works, as above named, are in a dilapidated condition, no attempt having being made to use them since the freshet of 1877.

The lock at Little's falls is a comparatively recent one, built to replace an old one washed out, and is so badly built that it is not worth repairing. The other locks are the original ones put in by the old navigation company, and are fairly constructed. One of them needs a new wall, and they all need new gates, cleaning out of sand, *débris*, etc. They are all 90 by 12 feet in the chamber.

The training-wall at Little's falls, originally built of small slabs of slate laid dry, has almost entirely disappeared.

The canal and mill-race at Snyder's mill, as well as the main canal below, require cleaning out of the *débris*, and possibly the removal of some projecting points of ledges.

I have endeavored to estimate the available power at this place in the following table:

Estimate of flow and power of the Shenandoah river at Harper's Ferry.

State of flow, (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.			
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*14 feet fall.*	*20 feet fall.*	*84 feet fall.*
Minimum	2,800	84	280	31.8	450	635	2,670
Minimum low season			476	54.1	750	1,080	4,540
Maximum with storage			2,520	286.3	4,000	5,725	24,000
Low season, dry years			540	61.3	860	1,225	5,150

As regards the utilization of this power, bed and banks are favorable to the construction of dams, but space for canals and buildings is sometimes limited. Nevertheless a large amount of power could be developed if necessary, and without great trouble. It is said that at Little's falls a fall of nearly 20 feet could be utilized; and just below the second lock, coming down, there is a mill, taking its water from the old canal, just above the lock, and using a fall of about 14 feet. Just above the canal leading behind Virginius island there is a mill, not now in operation, with a fall of 6 feet; and on Virginius island was formerly located the government rifle factory, taking water from the canal behind the island, above the double locks, with 15 feet lift, and discharging it across the island into the river, with a fall of 14 feet. By building a dam at the head of the island and turning the water into the old canal, this fall could be used without difficulty, and with considerable building-room on the island; and a much greater fall than 14 feet could be used, if necessary, depending on the height of the dam. At Bull's falls, although the descent is considerable, there are no facilities for races and buildings. Finally, below the point where the water was discharged from the rifle factory there is a fall of about 16 feet to the Potomac, about 14 of which is easily available, and is used at present by a flour-mill, with a wooden dam 400 feet long and 4 feet high, and a race of two or three hundred yards. The power used is perhaps 125 horse-power, and there is no trouble with want of water, although sometimes the machinery is stopped in freshets. It is said that the river has risen 25 feet at this place.

The power above described is worthy of notice. Facilities for transportation are excellent, and building-materials can be obtained in the immediate neighborhood.

Between Little's falls and the forks of the river there are no sites of importance and no tributaries worth mentioning. There were formerly a few small grist-mills on the main stream, with falls of 5 or 6 feet, but some of the dams were carried away in 1870 and have not been rebuilt.

On the South fork there is a flour-mill just above the junction with the North fork, using a fall of about 7 feet and 60 horse-power, with a wooden dam 400 feet long and 6 feet high. This is the best dam on the stream, the others being generally of brush. I should estimate the flow of the stream at this place, in cubic feet per second *per square mile*, at about the same as for Harper's Ferry, for which see table above

A mile or two above this mill there is a site once occupied, with a fall of 5 or 6 feet, and there are many similar ones farther up. Except at Kemper's falls, however—where the descent is 17 feet in 5,000—the falls are all small, and there are no mills on the stream with falls of over 9 feet. The quotations previously given render further remarks here unnecessary. There is doubtless a large amount of available power on the river, the principal trouble being due to the freshets, and this by no means serious.

Some of the tributaries of the South fork below the junction of the South and Middle rivers have rapid falls and offer some power, but they are all small streams and subject to considerable variation in flow. South river, which drains 257 square miles, has for some distance the same general character as the main stream, but is utilized more extensively for power. Its fall between Waynesborough and its mouth (at Port Republic), a distance of somewhere near 25 miles, is 220 feet, its elevation above tide at the former place being 1,259 feet. The upper part of the valley of the Shenandoah, and especially that part drained by the head-waters of the South fork, is, as already remarked, a limestone region. The streams here are generally fed by many bold and constant springs, and their flow is much more uniform than in the lower part of the basin; and this, together with the fact that the mills are small, will serve to explain why they are so much more extensively utilized than the main stream. The mills in the vicinity are uniformly grist-mills, with falls of from 5 to 10 feet, and, as a rule, 2 or 3 runs of stones. With few exceptions, most of the good sites in this vicinity are said to be occupied, there being mills on the main streams at intervals of a few miles. Middle river, which unites with South river, drains 770 square miles; but just above Port Republic it receives as an important tributary North river, draining 344 square miles, leaving about 425 square miles for the drainage area of Middle river above the junction. Both of these streams are fed by numerous springs, and are utilized to a considerable extent by grist-, flour-, and saw-mills, especially North river. The only freshets which are spoken of as having done any damage in this region are those of 1870 and 1877. The ordinary rise of the rivers in freshets in this neighborhood is from 2 to 6 feet, but in 1870 they rose in places 20 feet. The mills on these streams have, like those on South river, from 2 to 4 pairs of stones, which they can generally run all the time, with falls of from 5 to 10 feet.(*a*) North river is especially well utilized, having no fewer than 17 mills of various kinds, including the woolen mill of the Bridgewater Manufacturing Company, which uses a fall of 10 feet and 20 or 30 horse-power. Some very small tributaries, like Cook's creek and Mossy creek, heading in springs, run small mills. The fall from Port Republic to Mount Crawford, on North river, a distance of 16.35 miles, is 92.64 feet, or at the rate of 5.67 feet per mile.(*b*)

Perhaps the most prominent unimproved power in this neighborhood is one situated on Middle river (*c*) at Port Republic, just above where it joins the South river, although the fall is small. It is said that a dam 6½ feet high could be erected—the bed of the stream being solid limestone, and very favorable for its construction—giving an available fall of 8 feet, with banks favorable to the utilization of the power, and high enough to be perfectly safe in times of freshet. The width of the stream is about 350 feet, the drainage area being about 770 square miles. I should estimate the power about as follows:

State of flow, (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Remarks.
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	8 *feet fall.*	
Minimum	770	8	110	12.5	100	Flow more constant than on lower parts of Shenandoah.
Minimum low season			131	14.9	120	
Maximum with storage			680	77.3	620	
Low season, dry years			150	17.0	135	

The powers given in the table could be increased to some extent during twelve hours by drawing down the water in the pond. This site is owned by Mr. John W. Palmer, of Port Republic.

a My acknowledgments and thanks are especially due to Edward S. Kemper, esq., county surveyor of Rockingham county, and to G. W. Berlin, esq., of Harrisonburg, for detailed and valuable information regarding this part of the state.

b *Annual Report of the Chief of Engineers*, 1880, p. 675.

c There seems to be a little uncertainty regarding the names of these streams, some considering North river a tributary of Middle river, and others considering the former the main stream.

There is another site at Port Republic, on South river, where, with a dam $4\frac{1}{2}$ feet high and a race of 250 yards, a fall of 11 feet is said to be available. But, as the stream is only about one-third as large as Middle river, the power is small; before the war it was utilized. Both of these sites are very favorably located as regards transportation.

Finally, there is a third site, not used, about 2 miles above Port Republic, on North river, at Scott's ford. A fall of 6 feet was once used, with a dam 5 feet high, but in 1870 all of the buildings were carried away by the flood.

The North fork of the Shenandoah is similar in general character to the South fork, and its water-power is used only to run small grist- and saw-mills. Its fall, from the turnpike near Strasburg to the junction with the South fork, a distance of 13.32 miles, is 52.36 feet, or nearly 4 feet per mile. The following extract from the report of James Herron, reprinted in the *Annual Report of the Chief of Engineers* for 1880, page 668, will give an idea of the stream:

> From the forks the survey took up the North fork, through good bottom-lands, with but one short bluff before reaching Cedar creek. Above this the river seems to have cut through a spur of the Three-top mountain, round the base of which it winds, forming a good bottom in the bend. The valley-side, however, which was occupied by our survey, consists of high and steep slate rocks, forming a deep crescent of a mile and a half in extent, against which the river impinges with great violence in times of freshets; beyond this, very good bottoms continue to some distance above Strasburg.
>
> From near Strasburg to the mouth of Stony creek the North fork is extremely crooked, so much so indeed that no adequate idea of it can be conveyed. The tongues of land that form its numerous bends consist alternately of the high slate spurs from the Fort mountain, interlocked with equally high limestone ridges of the valley. There are 29 of these tongues, each one of which forms one or more small but highly-cultivated farms, in a distance of about 20 miles. The distance to the mouth of Stony creek, by the survey, is 42 miles 43.03 chains, showing an increase of distance amounting to $22\frac{1}{2}$ miles; the course of the stream is still longer, for the survey cut off the bottoms in the bends.
>
> The level of the river at the mouth of Stony creek was ascertained to be 515.53 feet above the Potomac, 757.96 feet above tide, and consequently 256 feet above its surface near Strasburg, which is at the rate of 6 feet to the mile; and did it run in a straight line it would be 12.8 feet. The latter is the general fall of the country, and has been found to hold with regard to the ridges and streams crossed by the line I have selected for a railroad, though remote from the river, the latter being left at Stony creek.

The mills on the stream are small, as will be seen by referring to the table of utilized power below. The dams are generally of wood or brush, and the mills have 2 or 3 pairs of stones, but, on account of leakage, are not able to run them all the year. The flow of the stream is quite variable, although some of its tributaries, especially in the upper part of the valley, are constant. The discharge at the mouth may be estimated at about 130 cubic feet per second when at its minimum, and about 180 cubic feet during the low season of dry years. The drainage area above Woodstock is about 618 square miles, and above Mount Jackson, 425. The rainfall is about the same as already given for the South fork.

The next tributary of the Potomac worthy of mention is the Antietam river, which has its sources in Franklin county, Pennsylvania, and flows nearly south through a distance of about 30 miles in a straight line, emptying into the Potomac in Washington county, Maryland, after draining an area of about 340 square miles. It drains a rolling and fertile country, but its declivity is uniform and uninterrupted by falls and rapids. It is utilized to a considerable extent, together with its tributaries, to run principally grist-, flour-, and paper-mills, and there are said to be no sites of importance unimproved, though some of the improved powers are at present idle. The flow of the stream is very variable, the freshets sudden and quite violent, and the powers small, as a rule. The drainage area above Funkstown is about 200, and above Hagerstown about 190 square miles.

Conococheague creek, which rises in Adams and Franklin counties, Pennsylvania, and pursues a general course parallel to that of the Antietam, joining the Potomac near Williamsport, in Washington county, Maryland, and draining an area of about 500 square miles, is the next tributary of importance. It resembles the Antietam in all essential respects, and, like it, is utilized for grist- and paper-mills, none of which are very large. Further particulars regarding the water-power of the stream could not be obtained with the time at disposal.

The remaining tributaries of the Potomac below the junction of the two forks are similar in their general characteristics, and drain the narrow longitudinal valleys between the ridges through which the Potomac breaks in this part of its course. Their fall does not seem to be great, and their power is unimportant. Their tributaries—secondary tributaries of the Potomac—often have, it is true, large falls, descending as they do from the ridges to the narrow valleys, but they are so small that they run nearly dry in summer. These streams have in some cases rocky beds, and rock is always found at a small depth; but their declivities, at least those of the primary tributaries of the Potomac, are on the whole uniform. The table of utilized power on pages 52 to 54 will show that they are used to some extent for power; but they are quite variable in flow, some of them being subject to quite heavy freshets, and their water-power may be said to be of little importance. The table on page 40 gives the drainage areas of some of these streams.

The following approximate elevations above tide are given by Chauncey Ives, esq., assistant engineer of the Cumberland Valley railroad:

	Feet.
East branch of Conococheague creek at Scotland, Pennsylvania, crossing of Cumberland Valley railroad	656
Falling Spring creek at Chambersburg, Pennsylvania, crossing of Cumberland Valley railroad	608
East branch of Conococheague creek at lower crossing of Cumberland Valley railroad	473
Buck Creek crossing of Cumberland Valley railroad	456
West Branch of Conococheague Creek crossing of Cumberland Valley railroad	500
Potomac River crossing of Cumberland Valley railroad	316

These elevations are referred to *high* tide in the Schuylkill river at Philadelphia.

It only remains to say a few words regarding the North and South forks of the Potomac.

The North fork takes its rise in Grant county, West Virginia, nearly on the line between West Virginia and Maryland, and for nearly its whole length forms the dividing line between those two states, pursuing a general course about 60 miles in length, and draining a mountainous area of about 1,300 square miles. The table on page 9 shows that its maximum discharge at Cumberland is over 700 times its minimum, a ratio which is exceedingly large for a stream draining such a large area (684 square miles without Wills creek) and which finds its explanation in the absence of lakes, the steepness of the mountain slopes, and the narrowness of the valleys, all characteristics which seem especially pronounced in this case. These great fluctuations in flow, however, are fatal to the extensive use of water-power on the stream. Reference to the table on page 9 shows that the minimum flow of the stream at Cumberland is about 25 cubic feet per second, or not enough to supply the canal, which terminates at this point; so that although there is a canal dam there (dam No. 8) 400 feet long and 8 feet high above low water, built of masonry, and with favorable sites for utilization of power, at some seasons no power could be obtained. The fall of the stream both above and below Cumberland is large, and the facilities for dams excellent, but its water-power is practically valueless.

Some of the tributaries of the North fork partake of its general characteristics, while others are said to be quite constant in flow, and to be fed by perennial springs; but all of them are comparatively small, and although their fall is often rapid, their power is still, on the whole, of no importance. The principal of these streams are Patterson's creek, which rises in Grant county, West Virginia, and flows northeast into Mineral county, draining an area of about 225 square miles, and Wills creek, which enters at Cumberland from the north, draining about 235 square miles, in Pennsylvania and Maryland; but no details could be obtained regarding them.

The South fork of the Potomac has its sources in Highland county, Virginia, and Pendleton county, West Virginia, near the head-waters of the James. Below the junction of the numerous forks which go to form the stream, and which pursue almost parallel courses through narrow valleys, it flows in a northeasterly direction through a narrow and fertile valley, draining a total area of 1,580 square miles. The drainage basin is thinly settled, and very inaccessible, not being traversed by a single railroad. The bed of the stream is mostly coarse gravel, and the banks are of loose sediment, and, on account of the sudden and local swells to which the river is subject, the channel is in a continual state of change. The facilities for dams are not very good, for they are liable to be undermined, and require extensive aprons. The fall of the stream is gradual, and varies from 7 to 8 feet per mile on the upper part (above Moorefield, about 54 miles from its mouth, measured along its course) to 4 feet per mile near the mouth. At no places are there concentrated falls of any magnitude, though in one place, about 20 miles below Moorefield, a rift is mentioned having a fall of 6 feet and over in 275 yards. The following table gives the elevations of four points on the stream :(a)

Slope of the South fork of the Potomac river.

Locality.	Distance from mouth.	Elevation above mouth.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet*
Mouth	0.0	0			
			29.6	127	4.3
Opposite Romney	29.6	127			
			24.0	151	6.3
Moorefield	53.6	278			
			12.0	97	8.1
....	65.6	375			

Very little definite information could be obtained regarding the water-power of the stream; but as regards that which is utilized the table on pages 52 to 54 shows that it is very small in amount. There are probably numerous sites where power could be developed by damming, but no particular ones can be mentioned. No information regarding the flow of the stream could be obtained, but the freshets are said to rise from 9 to 15 feet, and the flow is no doubt very variable, like that of the North branch.

The following table gives the drainage areas of the South branch and some of its tributaries:

	Square miles.
South branch at mouth	1,580
South branch at Romney	1,484
South branch below junction of forks	1,264
South fork of South branch at mouth	361
North fork of South branch at mouth	903
Middle fork of South branch at mouth	306
North fork of South branch above mouth of Middle fork	346

a *Eighth Report of the Board of Public Works of Virginia*, 1823.

Table of utilized power on the Potomac river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net
						Feet.	
Potomac river	Chesapeake bay	District of Columbia (a)		Paper (b)	1	34½	118
Do	do	do		Corn (b)	1	34½	92
Do	do	do		Fertilizers (b)	1	34½	65
Do	do	do		Flour (b)	5	172	730
Do	do	Maryland	Frederick	Flour and fertilizers (b)	1	6	37
Do	do	do	Washington	Flour (b)	1	17	25
Do	do	do	do	Saw (b)	2	16	......
Do	do	do	do	Sumac (b)	1	25	......
Do	do	do	do	Carpentering (b)	1	21	......
Do	do	do	do	Grist (b)	1	24	......
Do	do	do	do	Cement (b)	1	24	......
Do	do	West Virginia	Jefferson	do	1	8	40
Tributaries of	Potomac river	Virginia	Northumberland	Flour and grist	5	30	42
Do	do	do	do	Saw	3	30	36
Do	do	do	Westmoreland	Flour and grist	3	44	32
Do	do	do	King George	do	4	49	100
Do	do	do	Stafford	do	2	35	26
Do	do	do	Fauquier	do	8	167	115
Do	do	do	do	Plaster	1	24	27
Do	do	do	Prince William	Flour and grist	7	......	259
Do	do	do	do	Saw	2	38	30
Do	do	do	Fairfax	do	2	47	40
Do	do	do	do	Sumac	1	26	10
Do	do	do	do	Flour and grist	6	112	200
Do	do	do	Loudoun	do	32	490	529
Do	do	do	do	Saw	4	58	56
Do	do	do	do	Woolen	2	......	18
Do	do	District of Columbia		Flour and grist	3	40	125
Do	do	Maryland	Saint Mary's	do	7	100	156
Do	do	do	do	Saw	2	27	58
Do	do	do	Charles	do	1	23	8
Do	do	do	do	Flour and grist	7	115	96
Do	do	do	Prince George	do	8	112	149
Do	do	do	Montgomery	do	21	325	392
Do	do	do	do	Saw	2	27	34
Do	do	do	Frederick	do	17	233	177
Do	do	do	do	Blast-furnace	1	60	60
Do	do	do	do	Leather	1	12	4
Do	do	do	do	Machinery	1	5	3
Do	do	do	do	Woolen	3	47	26
Do	do	do	do	Flour and grist	84	1,197	1,710
Do	do	do	Carroll	do	29	400	469
Do	do	do	do	Saw	20	......	208
Do	do	do	do	Agricultural implements	1	10	8
Do	do	do	do	Woolen	2	......	15
Do	do	do	do	Blacksmithing	1	......	6
Do	do	do	do	Cheese and butter	1	9	8
Do	do	do	do	Fertilizers	1	10	40
Do	do	do	do	Iron foundery	1	......	6
Do	do	do	Washington	Flour and grist	51	697	1,192
Do	do	do	do	Saw	12	160	128
Do	do	do	do	Fertilizers	1	9	90
Do	do	do	do	Agricultural implements	2	19	24
Do	do	do	do	Blast-furnaces	c 2	56	90
Do	do	do	do	Furniture	1	22	20
Do	do	do	do	Paper	1	7	70
Do	do	do	Garrett	Flour and grist	4	57	62
Do	do	do	do	Saw	3	47	72
Do	do	do	do	Woolen	1	6	18
Do	do	do	Alleghany	Saw	2	30	35
Do	do	do	do	Flour and grist	13	196	309
Do	do	do	do	Printing	1	......	5
Shenandoah river and tributaries	do	West Virginia	Jefferson	Flour and grist	12	214	......

a Power returned by enumerator in District of Columbia is as follows—Paper: 1 mill, 30 feet fall, 95 horse-power used, net. Fertilizers: 1 mill, 32 feet fall, 27 horse-power used, net. Flour and grist: 6 mills, 30 to 40 feet fall at each; 636 horse-power used, net.

b Supplied with power from the canal.

c One not in operation.

Table of utilized power on the Potomac river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Shenandoah river and tributaries	Potomac river	West Virginia	Jefferson	Saw	4	65	66
Do	do	do	do	Iron foundery	1	4½	6
Do	do	do	do	Leather	1	4	7
Do	do	Virginia	Clarke	do	8	88	22
Do	do	do	do	Flour and grist	10	235	148
Do	do	do	do	Cheese and butter	1	2	1
Do	do	do	Frederick	Flour and grist	4	73	80
Do	do	do	do	Saw	1	10	25
Do	do	do	do	Woolen	6	....	....
Do	do	do	Warren	do	5	....	82
Do	do	do	do	Sumac	1	14	25
Do	do	do	do	Flour and grist	15	202	318
Do	do	do	Shenandoah	do	35	516	613
Do	do	do	do	Blast-furnaces	*a* 3	74	63
Do	do	do	do	Saw	23	322	304
Do	do	do	do	Forges	*a* 2	....	41
Do	do	do	do	Furniture	1	2¼	10
Do	do	do	do	Leather	2	15	10
Do	do	do	do	Machinery	1	12	12
Do	do	do	do	Woolen	1	10	15
Do	do	do	Page	Flour and grist	20	....	204
Do	do	do	do	Saw	2	12	24
Do	do	do	do	Leather	1	16	6
Do	do	do	do	Woolen	1	10	24
Do	do	do	Rockingham	Flour and grist	32	426	610
Do	do	do	do	Saw	14	180	213
Do	do	do	do	Leather	2	36	18
Do	do	do	do	Plaster	1	8	10
Do	do	do	do	Agricultural implements	2	11	38
Do	do	do	do	Furniture	1	22	12
Do	do	do	do	Fertilizers	1	6	12
Do	do	do	do	Blast-furnace	*b* 1	6	25
Do	do	do	do	Marble and stone works	1	10	13
Do	do	do	do	Forge	*b* 1	18	30
Do	do	do	do	Woolen	4	64	54
Do	do	do	Augusta	do	3	....	....
Do	do	do	do	Flour and grist	50	737	1,069
Do	do	do	do	Saw	12	190	270
Do	do	do	do	Agricultural implements	1	9	15
Do	do	do	do	Blacksmithing	1	14	2
Do	do	do	do	Foundery	1	12	6
Do	do	do	do	Machinery	1	12	6
Do	do	do	do	Sash factory	1	7	30
Do	do	do	do	Wheelwrighting	1	6	6
Other tributaries of	do	do	Clarke	Flour and grist	1	14	25
Do	do	do	Frederick	do	18	319	374
Do	do	do	do	Furniture	1	18	6
Do	do	do	do	Woolen	6	....	77
Do	do	West Virginia	Hampshire	Blast-furnace	1	15	15
Do	do	do	do	Woolen	3	78	52
Do	do	do	Jefferson	Saw	5	87	95
Do	do	do	do	Flour and grist	9	161	203
Do	do	do	do	Leather	1	1	1
Do	do	do	do	Paper	1	10	10
Do	do	do	do	Woolen	1	20	20
Do	do	do	Berkeley	Flour and grist	22	368	363
Do	do	do	do	Saw	10	136	115
Do	do	do	Morgan	do	5	51	81
Do	do	do	do	Flour and grist	4	43	76
Do	do	do	do	Woolen	1	13	12
Do	North branch Potomac	do	Mineral	Flour and grist	6	88	104
Do	do	do	do	Woolen	2	27	45
Do	do	do	Grant	Saw	5	68±	82
Do	do	do	do	Flour and grist	5	84	145
Do	do	do	do	Woolen	3	39+	35

a One not in operation. *b* Not in operation.

Table of utilized power on the Potomac river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
South branch Potomac river	Potomac river	West Virginia	Hampshire	Flour and grist	3	13	48
Do	do	do	do	Saw	2	22½	24
Do	do	do	Hardy	Flour and grist	1	4½	20
Do	do	do	Grant	do	2	15	35
Do	do	do	do	Woolen	1		6
Do	do	do	Pendleton	Flour and grist	8	73	88
Do	do	do	do	Saw	1	5½	10
Do	do	do	do	Woolen	1	6	15
Tributaries of	South branch Potomac	do	Hampshire	Saw	1	14	8
Do	do	do	do	Flour and grist	3	45	59
Do	do	do	Hardy	Saw	2	29	33
Do	do	do	do	Flour and grist	1	7½	18
Do	do	do	Pendleton	do	3	50	43
Do	do	do	do	Woolen	1	2	8
Do	Potomac river	do	Hampshire	Saw	9		96
Do	do	do	do	Flour and grist	12	180	137
Do	do	do	Hardy	do	9	148	100
Do	do	do	do	Woolen	1	10	6
Do	do (*a*)	do	do	do	2		11
Do	do	Pennsylvania	Adams	Saw	12	172	139
Do	do	do	do	Flour and grist	19	298	269
Do	do	do	do	Woolen	1		
Do	do	do	Franklin	Flour and grist	74	916	1,479
Do	do	do	do	Saw	21	271	203
Do	do	do	do	Leather	2	28	26
Do	do	do	do	Agricultural implements	2		22
Do	do	do	do	Furniture	1	4	25
Do	do	do	do	Machinery	1		5
Do	do	do	do	Paper	3	26	170
Do	do	do	do	Blast furnace	1	10	10
Do	do	do	do	Woolen	4	40	60
Do	do	do	Fulton	Flour and grist	18	260	357
Do	do	do	do	Saw	3	32	65
Do	do	do	do	Woolen	2	42	30
Do	do	do	do	Fertilizers	2	10	32
Do	do	do	Bedford	Flour and grist	1	16	16
Do	do	do	Somerset	Saw	2		37

a Perhaps tributary to South branch.

V.—THE SMALLER TRIBUTARIES OF CHESAPEAKE BAY.

Before proceeding to describe the Susquehanna river, there remain to be noticed a few small tributaries of Chesapeake bay, some of which, however, are notable on account of their utilized power, serving to run in part some of the largest manufacturing establishments in this part of the country.

Those streams entering the bay from the east may be dismissed with a few words. The region they drain is flat and often low, with a soil of clay and sand, and they belong to the class of sand-hill streams, their flow being quite constant, and the declivities, as a rule, uniform. They are utilized to a large extent to drive grist- and saw-mills, but their powers are all very small. The total power utilized is tabulated at pages 58 and 59, *infra*.

The streams from the west and north possess considerable power in proportion to their size, their principal part being, of course, above the fall-line, up to which they are often tidal. This fall-line, as remarked in the introduction, crosses the Potomac several miles above Washington, passes nearly through Baltimore, and follows the bay in a northeasterly direction, leaving Maryland not far from its northeastern corner, and probably passing through the northern part of the state of Delaware. Below the fall-line there are some small powers on streams belonging to the sand-hill class, and similar in character to those on the other side of the bay.

The rainfall over the entire region referred to may be taken at about 47 inches, of which 12 fall in spring, 13 in summer, 12 in autumn, and 10 in winter.

The first stream above or north of the Potomac which is worthy of special mention is the Patuxent river, which has its sources in Howard and Montgomery counties, Maryland, and pursues a southeasterly and then a southerly course, forming the boundary line between the counties of Howard, Anne Arundel, and Calvert, on its

left, and Montgomery, Prince George's, Charles, and Saint Mary's, on its right, emptying into the bay 18 or 20 miles above the mouth of the Potomac. It drains an area of about 960 square miles, and its length, measured in a straight line, is about 80 miles. It is navigable for 40 or 50 miles from its mouth, and crosses the fall-line, passing from the middle to the eastern or alluvial district, near Laurel, in the vicinity of which place there are several powers. Above this point the drainage area of the stream measures a little over 200 square miles, and includes a hilly and rolling country, with no lakes, a soil of sand and clay, and some limestone in parts. The flow of the stream is very variable, with heavy freshets and sudden rises, and a very small flow in the dry season. In 1868 a freshet occurred which carried away, it is said, every dam on the stream. The bed is often rock, sometimes overlaid with a thin layer of gravel, and the fall is quite rapid. The mills are not much troubled with ice, but the complaint is made that the flow is becoming more variable, the summer flow less, and the freshets more violent.

The following are the most important powers on the stream:

Near Laurel is the Avondale flour-mill, with a fall of 8 or 9 feet, and some 60 or 70 horse-power used. Just above it is the Laurel cotton factory, with a stone dam 300 feet long, 28 or 29 feet high, a race about 1,000 feet long, and a utilized fall of about 30 feet. A power of 200 horse-power is used, which can generally be obtained during only nine months or less, so that an engine of 150 horse-power is used in the dry season.(*a*) Judging from analogy, one would not expect the stream to afford over 5 gross horse-power per foot fall in the minimum low season, or from 7 to 8 in the low season of ordinary years. There is no artificial storage (except in the mill-ponds) in the basin of the Patuxent.

About a mile and a quarter above Laurel there is an unimproved power, consisting of a rapid fall amounting, it is said, to 20 feet or over in a short distance. I am unable to speak authoritatively of the value of this site.

The Guilford cotton factory, farther up, has a stone dam 200 feet long and 8 feet high, a race 2,500 feet long, and a utilized fall of 14 feet. The power used is 50 horse-power, which can be obtained during eleven months generally, while during the remaining month sometimes only one-half can be obtained. Steam-power is used during the dry season to the extent of 75 horse-power.(*b*)

There are other powers on the stream above this, including a woolen-mill, grist- and saw-mills, but they are all small. The statistics regarding them will be found tabulated at pages 58, 59.

The Patuxent receives as a tributary below Laurel the Little Patuxent, a stream draining some 60 or 70 square miles, and with one power worth naming, the Savage cotton factory, near Savage station on the Baltimore and Ohio railroad. The dam is 185 feet long and 18 feet high, the race is half a mile long, and the fall used is 55 feet, capable of being increased, it is said, to 60 feet. A power of 250 horse-power is used, and can generally, it is said, be obtained all the year, but probably by drawing down the water in the pond during the day-time.(*c*) There are said to be two unimproved sites on the Little Patuxent near this factory, with falls of 15 feet and over.

The next stream of importance is the Patapsco river, which is formed by the union of its North and South forks, and flows rather south of east, between the counties of Howard and Anne Arundel on the south, and Baltimore on the north, emptying into Chesapeake bay just below the city of Baltimore. Of its two branches, the North fork rises in Carroll county and flows south, draining about 129 square miles, and the South fork rises in Carroll and Howard counties and flows east between them, draining about 100 square miles. The total area drained by the Patapsco measures about 350 square miles, and lies almost entirely above the fall-line, so that the area valuable for water-power is greater than in the case of the Patuxent. The character of the basin is similar to that of the latter stream. It has no lakes or artificial reservoirs, and the flow of the stream is quite variable; but the freshets do not occasion very large rises of the water, on account of the fall of the stream, which is rapid for the greater part of its course, and is utilized for power to a considerable extent. The width of the stream averages 100 to 150 feet, and the rise in a heavy freshet is said seldom to exceed 6 or 7 feet in the lower part of its course. The bed is generally rock, the banks are abrupt or shelving, very little land is subject to overflow, and the facilities for power, so far as the location goes, are in every respect favorable. The Baltimore and Ohio railroad follows the stream closely from Relay Station almost to the source of the South fork, thus rendering every point easy of access.

The following are the powers on the stream:

At Relay Station, about 5 miles from Baltimore and 15 miles from the bay, is the Hockley flour-mill, the first power on the stream, and at the lower extremity of the fall caused by its crossing of the fall-line. The dam is of wood, 250 feet long and 8 feet high, almost entirely rebuilt in 1874, and the fall at the mill, 200 yards below, is 8 feet. A power of 100 horse-power is utilized, running 8 sets of stones. Full capacity can be secured during only nine months, the mill being run night and day, and in dry seasons only 5 or 6 sets can be run. The drainage area above this place being about 310 square miles, analogy would lead us to expect that the stream here would afford a power of about 8 horse power (gross) per foot fall in the minimum low season, and about 12 in the low season of ordinary years; but these figures may really be increased to some extent, during the day-time at least, by the storage effected by the numerous mill-ponds above.

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a Steam-power stated at 200 horse-power in statistics of cotton-mills.

b In Statistics of Cotton Mills the mill is stated to be on the North branch of the Patuxent river, the fall is given as 13 feet, the water-power used as 75 horse-power, and the steam-power as 50 horse-power. I am not able to say whether the information given me or these statements just given are in error.

c In Statistics of Cotton Mills this mill is given as on the Patuxent river. Fall stated at 55 feet; power at 200 horse-power.

The next utilized power is about a mile and a half above, at the Orange Grove mill, but between the two there is considerable fall in the river, amounting, it is said, to between 20 and 25 feet. Of this, a fall of about 15 feet was formerly used to run iron-works, but the dam was washed out in the freshet of 1868, and at present the site is idle. The remainder of the fall referred to has never been utilized.

The Orange Grove flour-mill (C. A. Gambrill & Co.) has a dam of wood and stone, 180 feet long and 15 feet high, built in 1857, and ponding the water over 5 or 6 acres, it is said. A fall of 12 feet is used by 5 turbine wheels, affording 250 horse-power. The mill has 23 sets of stones, of which 13 are run by water and 10 by steam exclusively. The full capacity of the water-wheels can be utilized during only about six months, the capacity becoming at times less than one-half. According to what has been said regarding the capacity of the stream, a power of 144 horse-power gross would be all that could be expected here in the low season of ordinary years; and as the mill runs night and day there is no storage except what is due to the mills above. During the day-time it is said that water always wastes, a large amount being let down by the mills above.

Above this mill there are said to be two unimproved powers, the first with a fall of some 25 or 30 feet, which has never been utilized; the second with a fall of some 11 feet, formerly used, but now entirely unimproved. The latter site is at Ilchester. From the above remarks regarding capacity, an idea can be formed of the available power at these places.

The next power is the Thistle cotton factory, but no details could be obtained regarding it. The fall is said to be about 12 feet.(a)

Next above is Gray's cotton factory, at Ellicott City, where a fall of about 9 feet is used, and a power of 75 to 80 horse-power is obtained.(b) A 50 horse-power steam-engine is used in the low season. The dam is of wood, about 172 feet long and 8 feet high, ponding the water over about 6 acres.

Just above is the Patapsco mill of C. A. Gambrill & Co., with a fall of 12 feet and 250 horse-power. The mill has 12 pairs of stones run by water and 10 by steam, a 200 horse-power engine being run all the time. Full capacity can be obtained for less than six months, as would be expected. The dam is of wood and stone, 180 feet long and 3 feet high, built in 1879 at a cost of $2,000.

Next comes an unimproved site of the Union Manufacturing Company, with an available fall said to amount to 15 feet in three-quarters of a mile. The site was once used, but the works were washed away.

Next above is the cotton factory of the Union Manufacturing Company of Maryland. The dam is of wood, 185 feet long and 10 feet high, and was built in 1867 at a cost of about $15,000. It ponds the water over about 17 acres, and from it a race 2 miles in length leads to the mill, where the fall is 30 feet. A power of 310 horse-power is utilized, and can be obtained all the year, so that no steam-power is used.(c) The mill is run ten hours a day, and water generally wastes over the dam except at very low stages. The drainage area above this site, as well as above the three preceding and the three following, may be taken as 275 square miles, so that we may estimate the flow at about 10 per cent. less than at Relay Station—that is, we should expect the stream to afford about 7 horse-power (gross) per foot fall in the lowest season in a series of years, and 11 in the low season of ordinary years, an estimate which agrees remarkably well with the power stated for the Union factory, when we consider the loss from imperfect motors, and the fact that the supply during the day-time is greater than at night, on account of the mills above.

Below Elysville is the Alberton cotton factory, with a fall of 19 or 20 feet, and using 430 horse-power, which, however, can be obtained only during eight months.(d) During the remaining time, steam-power is used to the extent of 175 horse-power on the average, and sometimes as much as 300 horse-power. The dam, which is 2,000 feet above the mill, is of wood, 160 feet long and 19 feet high, and was built in 1867 at a cost of $30,000. In the summer the water is drawn down in the pond during working-hours.

Next comes a site formerly used by a flour-mill, but now entirely unimproved, known as "Ellicott's old upper mill", with a fall of 8 or 9 feet.

At Elysville is a second unimproved power, once used by a woolen-mill, and afterward by a grist-mill, the fall being about 10 feet.

Above this there are several small powers, some improved and others not, but none of them remarkable, so far as could be learned. The fall is said to be rapid all along the stream, but the declivity is gradual.

On the two branches of the Patapsco there are a number of small mills, generally grist- and saw-mills, with some paper- and woolen-mills, but none of them are large. On the North fork, for instance, J. A. Dushane & Co. have a paper-mill with a fall of 9 or 10 feet and are using about 100 horse-power, but this can be obtained during only from five to eight months. There are, of course, some sites not used, offering small powers. Near Sykesville there is said to be one, formerly used, with a fall variously stated at from 12 to 19 feet.

The Patapsco river is the most important manufacturing stream of Maryland, and its water-power is excellent, as we have seen. No other stream in the state, with the exception of the Potomac, offers so many advantages or so many favorable sites for power.

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a Fall given as 12 feet and power as 221 horse-power, in returns of enumerators.

b Power given as 120 horse-power in returns of enumerators.

c Fall given as 26 feet and power as 369 horse-power, in returns of enumerators.

d Fall given as 17½ feet and power as 480 horse-power, in returns of enumerators. Steam-power, 350 horse-power.

Mention should be made here of two small streams which enter the lower part of the Patapsco, and are utilized to a considerable extent, viz, Gwynn's falls and Jones' falls. They are very small streams, very variable in flow, and really of almost no value for power. They have, however, considerable fall, and are utilized by a number of mills which run about half the year at full capacity by water-power, and during the rest of the time either use steam-power extensively or use very little power of any kind. On Gwynn's falls there is a flour-mill with a fall of 18 feet, and 75 horse-power during about seven months; above it is an unimproved privilege with a fall of about 16 feet; and above that are two flour-mills fed from one dam, one with a fall of 22 feet, and 100 horse-power during eight or nine months, and the other with a fall of 18 feet, and 60 or 75 horse-power during six months. This last site is only half a mile above Baltimore. Above it, and below Wetherdsville, is an unimproved privilege formerly used by a flour-mill, with a fall of 20 to 25 feet. Farther up are the Ashland woolen-mills, at one of which the fall is 22 feet, and the power 80 horse-power during about nine months, and at the other the fall is 28 feet, and the power 70 horse-power during nine months. Above, we come to the Powhatan cotton factory, where a fall of 22 feet is used, with 75 horse-power during, in some years, less than six months. Finally, there are a few grist-mills near the head-waters. Although used to such an extent, the water-power of the stream is of little value, because the flow is so variable that no dependence can be placed on the power, and steam must be relied on principally. Jones' falls is a still smaller stream, and is used by the city of Baltimore for supplying the city with water, so that, although there were formerly several mills on the stream run by water-power, they are now almost entirely run by steam, and the water-power of the stream is valueless.

The only other tributary entering from the west which is worth mentioning is Gunpowder river, a very short stream, being formed only a few miles from its mouth by the union of Big and Little Gunpowder creeks, or "falls", as many creeks in this neighborhood are called. Big Gunpowder falls drains an area of about 275 square miles, lying in Baltimore and Carroll counties, and comprising a rolling and hilly country. The power at its mouth may be estimated at about the same as that of the Patapsco at Elysville, that is, at about 7 horse-power gross in the lowest season, and about 11 in the low season of ordinary years; but the lower part of the stream is not available for power, as one of the reservoirs to supply the city of Baltimore has been located on the stream and all the water-rights below the proposed site have been purchased by the city, including power formerly used by several metal-working establishments, one of which, the Gunpowder Copper Works, is still running with what water can be obtained. Above the reservoir site the stream has a uniform declivity, and a bed of gravel and sand, with rock sometimes at the surface. Considerable power is utilized, there being a number of small grist-, saw-, paper-, woolen-, and other mills on the stream and its various tributaries. The most important powers are the following: At Phœnix there is a cotton-mill, but for some reason it has not been running for six or seven years, although everything is said to be in good order. The fall is 12 or 15 feet, but the power I am unable to estimate. The Warren factory, another cotton factory, has a stone dam 300 feet by 12, and uses a fall of 14 feet, with 175 horse-power during most of the time, it is said, while steam-power is used in summer to the extent of 100 horse-power. A grist- and a saw-mill are run from the same dam. Above this there are a number of paper-mills, arranged to utilize all the power available during the winter, and sometimes getting full capacity during only three months. Thus, the Marble Vale mill, near Phœnix, has a fall of 9 feet and 120 horse-power; the Rock Dale mill, 20 feet and 150 horse-power; and there are other similar powers. At many of them steam is used during the summer, and often during a much longer period. There are a number of unimproved privileges on the stream; one at Monkton, where there was formerly a mill; one below the Rock Dale mill, said to have a large fall, and others farther up. The volume of water, however, is very small in the summer time.

Western run and Little Gunpowder creek, the latter draining about 73 square miles, are the principal remaining tributaries. They are utilized to a considerable extent, but the powers are so small as to call for no further comment.

Crossing the Susquehanna, a few of the small streams entering the bay from the north are utilized to a considerable extent for power, but their flow is very variable, and only a small amount of power is available in the low season. Principio creek runs an iron-furnace with a fall of 32 feet, and several grist- and saw-mills; North East creek and its tributaries run several woolen-mills, grist- and saw-mills, and the works of the McCullough Iron Company at North East. None of the powers are large. One site not used, on North East creek, known as Gilpin's falls, has the large fall of not less than 120 feet in a quarter of a mile, the stream pouring over masses of rock down a narrow valley, and forming a very picturesque spot. Although quite a resort for excursionists, the place is of little value as a site for power, because the stream is so small that in summer it will afford only about 1 horse-power per foot fall. The total area drained by North East creek is about 65 square miles, but probably not over half of this lies above Gilpin's falls.

Big Elk creek, which drains 76 square miles, having its sources in Chester county, Pennsylvania, is similar in character to those already described, and is utilized for cotton-, woolen-, grist-, saw-, and paper-mills, and iron-works. At the works of the McCullough Iron Company, near Elkton, a fall of 20 feet is used, with a dam 16 feet high, and about 65 horse-power is obtained during ten months or thereabout, probably by drawing down the water in the pond, which is large. There are three unimproved sites on the stream where power could be obtained by damming, but no abrupt falls. At these places powers of from 20 to 40 horse-power could probably be developed during the greater part of the year.

Little Elk creek, which joins the Big Elk to form Elk river, drains only about 34 square miles. It is quite extensively used for flour-, paper-, and saw mills, and its fall is estimated at nearly 200 feet in its course through Cecil county, Maryland. There are several unimproved sites having quite large falls, viz, one near tide-water, said to have a fall of 24 feet; one just above Harlan's paper-mill, said to have over 30 feet fall in less than a mile; and smaller ones above.

The following table gives statistics regarding the utilized power on the streams we have been considering:

Table of utilized power on small tributaries of Chesapeake bay.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries to	Chesapeake bay	Maryland	Worcester	Flour and grist	2	15	22
Do	do	do	Somerset	do	1	3	12
Do	do	do	Wicomico	do	17	107	238
Do	do	do	do	Saw	21	122	287
Do	do	do	Dorchester	do	10	90	112
Do	do	do	do	Flour and grist	8	75	96
Do	do	do	Talbot	do	5	68	99
Do	do	do	Caroline	do	16	182	281
Do	do	do	do	Saw	10	....	120
Do	do	do	Queen Anne	Flour and grist	8	115	205
Do	do	do	do	Woolen	1	13	50
Do	do	do	Kent	Flour and grist	8	88	174
Do	do	do	Cecil	do	20	286	393
Do	do	do	do	Furnace	1	38	50
Do	do	do	do	Saw	7	103	154
Do	do	do	do	Agricultural implements	1	10	6
Do	do	do	do	Paper	3	52	150
Do	do	do	do	Cotton	1	10	40
Do	do	do	do	Iron-works	3	74	450
Do	do	do	do	Woolen	2	....	15
Patuxent river	do	do	Anne Arundel	Flour and grist	2	20	65
Do	do	do	Prince George's	Cotton	1	30	200
Do	do	do	Montgomery	Flour and grist	3	62	128
Do	do	do	Howard	do	2	20	46
Do	do	do	do	Cotton	1	14	50
Do	do	do	do	Saw	1	8	14
Tributaries of	Patuxent river	do	Calvert	Flour and grist	2	21	16
Do	do	do	do	Saw	1	8	20
Do	do	do	Anne Arundel	do	1	[illegible]	10
Do	do	do	do	Flour and grist	3	54	37
Do	do	do	do	Cotton	1	55	250
Do	do	do	Prince George's	Saw	1	10	15
Do	do	do	do	Flour and grist	3	49	82
Do	do	do	Montgomery	do	5	111	71
Do	do	do	do	Saw	2	38	35
Do	do	do	do	Agricultural implements	1	18	20
Do	do	do	Howard	Flour and grist	1	12	30
Patapsco river	Chesapeake bay	do	Baltimore	Cotton	1	10	....
Do	do	do	do	do	1	[illegible]	75
Do	do	do	do	do	1	30	310
Do	do	do	do	Flour and grist	1	12	250
Do	do	do	do	do	1	12	250
Do	do	do	Howard	do	1	8	100
Do	do	do	do	Cotton	1	19	430
Tributaries of	Patapsco river	do	Baltimore	Flour and grist	16	301	468
Do	do	do	do	Saw	3	49	28
Do	do	do	do	Cotton	1	22	75
Do	do	do	do	Needles and pins	1	7	30
Do	do	do	do	Woolen	2	50	150
Do	do	do	do	Dyeing and cleaning	1	10	14
Do	do	do	Howard	Flour and grist	11	196	143
Do	do	do	do	Saw	5	74	55
Do	do	do	do	Agricultural implements	1	17	12
Do	do	do	do	Paper	1	20	100
Do	do	do	Carroll	Flour and grist	27	425	419
Do	do	do	do	Saw	13	203	153
Do	do	do	do	Paper	3	40	94

Drainage basins of the Susquehanna and Delaware rivers and of the Coast streams of New Jersey.

Table of utilized power on small tributaries of Chesapeake bay—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Patapsco river	Maryland	Carroll	Woolen	1	9	28
Do	do	do	do	Leather	1	12	
Do	do	do	Anne Arundel	Flour and grist	1	12	30
Other tributaries of	Chesapeake bay	do	Baltimore	Copper-rolling	1		
Do	do	do	do	Flour and grist	27	641	561
Do	do	do	do	Saw	22	398	274
Do	do	do	do	Cotton	1	14	175
Do	do	do	do	do	1	25	160
Do	do	do	do	Blast-furnace	1	8	60
Do	do	do	do	Paper	15	245	596
Do	do	do	do	Woolen	2	73	162
Do	do	do	Carroll	Flour and grist	5		64
Do	do	do	do	Paper	1	18	75
Do	do	do	Harford	Flour and grist	18	280	429
Do	do	do	do	Saw	4	57	62
Do	do	do	do	Fertilizers	1	15	25
Do	do	do	do	Carriage and wagon materials.	1	19	22
Do	do	Delaware	Sussex	Flour and grist	11	80	283
Do	do	do	do	Saw	10	95	258
Do	do	Pennsylvania	Chester	Agricultural implements	1	12	10
Do	do	do	do	Fertilizers	1	26	25
Do	do	do	do	Flour and grist	19	351	285
Do	do	do	do	Saw	9	169	126
Do	do	do	do	Paper	4	67	146

VI.—THE SUSQUEHANNA RIVER AND TRIBUTARIES.

THE SUSQUEHANNA RIVER.

The Susquehanna, the largest stream on the Atlantic slope of the United States, though by no means the most important as regards water-power, has its sources entirely beyond the region of corrugations composing the eastern part of the Appalachian mountain system, on the elevated plateau which bounds that system toward the west and north, forming the water-shed between the waters flowing north and west into the Saint Lawrence, the Mississippi, and the great lakes, and those flowing into the Atlantic streams of this country. The river rises in Otsego lake, in Otsego county, New York, at an elevation above the sea of about 1,193 feet.(*a*) Its course lies first in a southwesterly and westerly direction, through Otsego, Chenango, Broome, and Tioga counties, New York, and with a portion of its course in Susquehanna county, Pennsylvania, and its volume is rapidly swelled by large tributaries, until, when it finally leaves New York in Tioga county, bending to the south to pursue a southerly course through Pennsylvania, its drainage area, just below the mouth of the Chemung, measures 7,463 square miles. In its course through Pennsylvania the stream passes through Bradford, Wyoming, Luzerne, Columbia, Montour, and Northumberland counties, to its junction with its West branch, whence it flows nearly south between Northumberland Dauphin, and Lancaster counties on the east, and Snyder, Juniata, Perry, Cumberland, and York counties on the west, passing then into Maryland, flowing between Cecil county on the east and Harford county on the west, and emptying into Chesapeake bay at its northern extremity. The total drainage area of the stream, which measures not less than 26,233 square miles, is divided as follows between the three states through which it flows: New York, 6,267; Pennsylvania, 19,711; Maryland, 255 square miles.(*b*) The principal large tributaries of the stream drain the following areas:

	Square miles.
Chenango river	1,540
Chemung river	2,518
West branch of the Susquehanna river	6,466
Juniata river	3,223

a Geological Survey of New York, Part III, p. 238 (1842).

b These are from my own measurements. It is to be mentioned, however, that Mr. Gannett, the geographer of the census, gives the drainage area of the Susquehanna as 27,655 square miles.

The river flows by a number of important cities and towns, among which may be mentioned the following: Binghamton, New York, at the mouth of the Chenango; Owego, New York, at the mouth of Owego creek; Athens, Pennsylvania, near the mouth of the Chemung, really on the latter stream; Towanda, Tunkhannock, Pittston, Wilkesbarre, Berwick, Bloomsburg, Danville, Northumberland (at the mouth of the West branch), Sunbury, Dauphin, Harrisburg, Marietta, Middletown, and Columbia, Pennsylvania; Port Deposit and Havre de Grace, Maryland. It is not navigable above its crossing with the fall-line, very near its mouth, but a canal extends along the stream as far up as Wilkesbarre, the river being navigated to some extent in the pools of the canal dams. When we add that the stream is closely followed for almost its entire length by railroads, it will be evident that the facilities for transportation leave nothing to be desired.

The drainage basin of the stream is very varied in character, embracing as it does such a large area. In the state of New York the stream, with its tributaries, flows through a rolling and sometimes rather broken country, forming the plateau bounding the mountain region on the north. Its declivity in this part of its course is very uniform, its bed gravel or sand, with seldom a rock ledge, and its banks moderately high, shelving, and not very extensively subject to overflow. It flows over beds of drift and offers little power. Passing into Pennsylvania, it enters the mountain region, and its course is in places very tortuous as it winds among the parallel ranges of hills. Its fall is gradual, as before, and its bed generally drift materials—gravel, sand, and bowlders. The banks are generally high, and there are few bottoms subject to extended overflow, although the river is subject to rises of 30 feet or thereabout. Below the mouth of the West branch the fall of the stream becomes rather more irregular, and at several places there are rapids where the stream flows over a rock bottom. In the lower part of its course, from Marietta to Havre de Grace, the stream "occupies a deep broad valley, varying in width from a few hundred feet to more than a mile, and on either shore it is for the most part bounded by rocky bluffs supporting table-lands at an elevation of from 100 to 500 feet above its waters".(a) The fall in this part of its course is quite rapid, the stream is often very wide, and the channel is dotted with islands and rocks. For a more detailed description of the river I can not do better than quote that given by Professor H. D. Rogers, in his *Geology of Pennsylvania:*

That portion of the Susquehanna river which flows near the northern boundary of the state passes from its sharp elbow, called the "Great Bend", to the mouth of its affluent, the Chemung river, through a charming broad valley, bounded by soft slopes terminating in wide table-shaped hills. It is a fertile and very beautiful district; and with its westward extension, the plain of the Chemung river is rapidly becoming one of the most attractive agricultural districts of New York. From the mouth of the Chemung river to Pittston, where the river suddenly turns at a right angle on entering the Wyoming coal-field, it flows, with many bendings, along a deep and picturesque valley, almost identical in its features with that of the corresponding stretch of the Delaware, the main difference being that the bed of the valley is wider and the hill-sides confining it less mountainous. From the mouth of the Lackawanna at Pittston, where it enters, to Nanticoke, where it leaves the beautiful Wyoming valley, the scenery along the river is wholly different. It flows through a broad and almost perfectly level, smooth plain—the Wyoming and Kingston flats—composed of a deep bed of diluvium or drift. On either side of this plain rise the rolling hills of the coal-basin, and behind these the long gentle slopes of the high mountain barriers which frame in the whole scene. At Nanticoke the river turns abruptly northward out of the coal-basin, through its steep barrier, by a highly picturesque pass, and then sweeps again as suddenly westward, to run for several miles in a closely-confined trench between the outer and the inner ridges of the basin. It does not, however, run round the western end of this, but at the ravine of the Shickshinny turns suddenly southward, and cuts across its point, leaving a high insulated hill of the coal strata on its western or right-hand side. Disengaging itself by a fine pass from the southern barrier of the coal-basin, it passes out into an open valley and makes another rectangular bend, to run once more toward the west, parallel with the Nescopeck mountain, which it follows to the neighborhood of Catawissa. Beyond this point it maintains its general course westward, somewhat south, parallel with the southern base of Montour's ridge, all the way to Northumberland, where it is joined by its great tributary, the West branch. In some portions of this long reach of the river the scenery adjoining it is uncommonly rich and pleasing. A remarkably fine view up the river is presented from the hills on its west bank, a little below the mouth of Fishing-creek.

Between Northumberland and the Kittatinny valley the river leads us through many striking scenes. It is studded with many little islands, most of which are covered with trees or bushes to the water's edge, and it is here a wide and majestic river, flowing alternately, for long reaches, across highly-cultivated belts of country, and past the ends of steep and rugged mountains. Passing out from the mountains, it traverses a beautiful country in the Kittatinny valley, dividing Dauphin from Cumberland county. Quitting the limestone valley, the river next traverses the red-shale belt, between the villages of Highspire and Bainbridge, crossing a rather monotonous country, except at the Conewago falls, or rapids, where numerous hard trap-dikes impede its course, and cause it to rush in wild tumult, by deep and dangerous sluices, for a long distance between black and jutting reefs. At Chicques ridge, one mile above Columbia, the river leaves the smoother country, and passes between a range of high and picturesque crags. With two or three intermissions, caused by the softer limestone valleys which it next crosses, it runs the whole way thence to the vicinity of Port Deposit, or nearly to the head of Chesapeake bay, between steep naked and half-naked hill-sides, rising from 200 to 400 feet above its channel. In some parts of this long reach, as at the mouth of the Conestoga, the river is greatly dilated, and is filled with rocky islands and projecting reefs. In other localities its rugged banks approach, and the river rushes with tremendous force, especially during freshets, through these deeper gorges. The traveler, who finds only a rough and very toilsome path along its eastern shore from Turkey Hill to Port Deposit, a distance of more than 30 miles, will choose to descend it by its right bank along the tow-path of the canal. He will pass an almost unbroken succession of interesting rocky scenes, affording much geological instruction; and he will witness many beautiful bits of river perspective, but he will find himself pent in all the way between the bold river hills.

a Rogers' *Geology of Pennsylvania*, p. 184.

The declivity of the river is shown in the following table:

Locality.	Distance from mouth.	Elevation above mean tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0.0	0	12	69	5.75
State line	12.0	69			
Crossing of Peachbottom railroad(*a*)	17.5	86			
Mouth of Fishing creek	20.0	100	31	155	5.0
Mouth of Muddy creek	22.0	119			
Columbia dam, water below	43.0	224			
Columbia dam, crest	43.0	231	14	23	1.6
Below Conewago falls	57.0	254			
			2±	19	9.5±
Above Conewago falls	59.0	273			
			10	25	2.5
Harrisburg (*b*)	69.0	298			
Rockville, crossing of Pennsylvania railroad(*c*)	75.0	305	15	38	2.5
Clark's Ferry dam, water below	84.0	336			
Clark's Ferry dam, crest	84.0	343			
Liverpool	99.0	378	38	79	2.1
Seelin's Grove	116.0	421			
Sunbury dam, water below	122.0	422			
Sunbury dam, crest	122.0	429			
Nanticoke dam, water below	174.0	509	52	80	1.5
Nanticoke dam, crest	174.0	515			
Wilkesbarre	183.0	521			
Mouth of Lackawanna river (*d*)	190.0	536			
Mouth of Tunkhannock creek (*d*)	211.0	581			
Mouth of Mehoopany creek (*d*)	223.0	604	104	229	2.2
Mouth of Wyalusing creek (*d*)	244.0	646			
Mouth of Wysox creek (*d*)	257.5	687			
Towanda (*d*)	262.0	700			
Athens, on Chemung river (*d*)	278.0	744			
Lake Otsego, source of river	422.0	1,193	144	449	3.1

a This elevation is given by Mr. S. M. Mansfield, superintendent.
b This elevation is a mean between those furnished by Chauncey Ives, esq., assistant engineer of the Cumberland Valley railroad, and Alfred Walter, esq., assistant engineer of the Northern Central railroad.
c For this elevation I am indebted to Mr. William H. Brown, chief engineer.
d For these elevations I have to thank Robert H. Sayre, esq., superintendent and engineer of the Lehigh Valley railroad. The remainder of the elevations are to be found in the volume *Tide Levels*, published by the Pennsylvania geological survey.

There is some discrepancy in regard to the *datum planes* used in different cases, hence the above heights are subject to some error; but as the length of the stream between the points mentioned was determined only by measurement from a map, this error is unimportant.

The flow of the stream is regulated to some extent by a number of lakes in its basin, but they are so small that their effect is hardly perceptible, so that the river is subject to considerable variations in volume. The freshets rise in places to a height of 30 feet, and the minimum flow would probably be quite low were it not for the very large area drained by the stream. No gaugings of the flow could be obtained, so that I am obliged to depend entirely upon estimates. The facilities for storage may be called good, and there are numerous sites where storage reservoirs might be constructed; but although by their means the flow of the small tributaries of the stream might easily be regulated so that the maximum flow available might be utilized, it would be a stupendous undertaking to endeavor to do this for large areas like those drained by either fork of the stream. The power estimated as the "maximum with storage" must therefore be looked upon as practically altogether unavailable.

A large portion of the drainage basin of the river, namely, that part in the central and western parts of Pennsylvania, is very well wooded, and lumbering is carried on very extensively; other parts of the basin are almost cleared of forests over considerable areas.

The mean annual rainfall over the basin is about 39 or 40 inches, of which 10 fall in spring, 12 in summer, 9 or 10 in autumn, and 8 in winter—a distribution quite favorable for constancy of flow.

As the river is descended from its source in lake Otsego, no important water-powers are met for many miles. I did not personally examine the stream above the town of Susquehanna, having been told by every one whom I questioned that there were no powers of note above that place. In cases where a stream flows with a uniform declivity, and with no large utilized powers, it was of course impossible for me to obtain much information; for the rule is that in such cases, if the fall is great enough, power can be obtained by damming wherever the banks are good and where there would be no difficulty on account of flowage. The returns of the enumerators show that the stream is well utilized in the part of its course referred to, but the powers and the falls also are generally small. I heard of no special sites not used, and therefore did not visit this part of the river. The dams, I was told, are generally primitive brush or crib dams, and many of the mills have falls of only 3 or 4 feet.

At Susquehanna there are two powers, the upper one, a grist- and planing-mill, using a fall of 3 feet, and the lower one, a grist-mill, with a fall of 4 feet.

The first important power on the river is at Binghamton, New York. A dam, built of crib-work, 450 feet long and 5½ feet high above low water, extends entirely across the stream, ponding the water for about 2 miles, with an average width of perhaps 500 feet. A race 500 feet long supplies power to the following mills:

1. Saw- and planing-mill, cabinet- and box-shop; 2. Doolittle's grist-mill; 3. Machine-shop, wood-working machinery, wool cards; 4. Tannery; 5. Factory of children's sleds, carriages, etc.

The power is owned jointly by the owners of these different establishments, and the method of distributing the water is not very clear. Full capacity can be obtained during about ten months, and it sinks during the low season as low as one-half. All the mills use a fall of about 5½ feet, and a total power of something like 250 or 300 horse-power. In the low season no water runs over the dam in the day-time, but the pond is not large enough to store all the flow during the night. The race is about 80 feet wide, and 6 feet deep at its head.

The drainage area of the stream above Binghamton measures no less than 2,279 square miles. The volume of water must therefore be considerable—perhaps, when at its minimum, about 340 cubic feet per second, affording a gross power, with a fall of 5½ feet, of about 215 horse-power.

Below Binghamton there is no power of importance on the river for a very long distance. Above the Pennsylvania line there are some ripples or rapids, and several small mills, with falls of a few feet. Such mills are, of course, "drowned out" in times of high water. The stream in this part of its course is from 500 to 1,000 feet wide.

The stream has been surveyed from the state line to Nanticoke dam, below Wilkesbarre, by the United States Engineers, under the direction of Colonel J. N. Macomb, whose report is to be found in the *Annual Report of the Chief of Engineers* for 1880, Appendix F, page 594. Between the mouth of the Chemung, just below Athens, and Towanda there have been three mills, no longer in existence, but the falls were small and the power unimportant. In fact, we may say that there is no power on the river from the New York line to Nanticoke, and as the table of declivity shows, the fall of the river in this part of its course is scarcely over 2 feet to the mile. The ripples separating the long and navigable ponds are very short, and have falls generally of but a few inches, "not often reaching 2 feet, and seldom exceeding it". There are places where, by building a dam which would pond the water for several miles, falls of 5 and even 10 feet could be obtained, and there are a few mills on the river now. For instance, beginning about a mile below Ulster there is a fall of 6 feet or so in a little over 2 miles; a few miles below Mehoopany, at Horse Race falls and below, there is a fall of 8 feet or so in about a mile; and there are a few small mills on the river in the distance referred to, with falls of not over 7 feet. Although power could no doubt be developed by building dams, and although the volume of water is large, yet it is clear that on account of the considerable width of the river and the small falls obtainable, the facilities for water-power are decidedly poor, especially when we consider the heavy freshets, and particularly the ice-jams, to which the river is subject. It is found much more economical to utilize the small tributaries instead of the river itself.

It should be mentioned here that there was at one time a canal along the Chemung and the Susquehanna, above Wilkesbarre, and that there were several canal dams on both streams, now destroyed. It is said that they averaged 8 or 10 feet in height, but I was not able to determine this point definitely.

The Nanticoke dam, which backs the water half way up to Wilkesbarre, or a distance of about 4 miles, is the first dam below Binghamton extending quite across the river. It is a crib-dam, 900 feet long, and 6 feet high above low water, and its pool is used for navigation for several miles. A certain amount of power is available at the dam, but the fall is so small that there would probably be frequent interruptions on account of high water. The quantity of water diverted for the purpose of feeding the canal could not be accurately ascertained, but it is no doubt very small compared with even the low-water flow of the river. I should estimate the volume of water in the stream during the low season of dry years at about 3,300 cubic feet per second, which would correspond to about 375 gross horse-power per foot fall. The drainage area above this point is about 9,850 square miles, and the rainfall 39 inches—10 in spring, 11 in summer, 10 in autumn, and 8 in winter. As this site, however, is situated in the coal region, where fuel is cheap, and as the location otherwise is said to be unfavorable, it is not an important available power.

From Nanticoke to the mouth of the West branch there is no power of importance on the stream. There are a few small ripples where, by building dams, falls of from 5 to 10 feet could perhaps be obtained, but none of them are of any value, not even Berwick falls, the most important, where the fall is about 3 feet in 200 yards, over some rock ledges.

It may be as well to mention here the fact that at various points along the Pennsylvania canal, which extends not only along the main Susquehanna from Columbia to Wilkesbarre, but also along the West branch and the Juniata river, power is utilized from the canal to a small extent, the water being either discharged into the river or around the locks to lower levels. The amount of power thus utilized is at present very small, and there is a quite large traffic on the canal, so that the question of water-power is of minor importance. It is said, however, that considerable power could be utilized at the locks, where water is continually wasting to the levels below. The company has

hitherto been disinclined to lease water for power, and the few leases that they have granted are mere sufferances. The company guarantees nothing, and simply allows the mills to use the surplus water, subject to interruption at any time, according to the pleasure of the company. The mills pay an annual rent, varying according to the fall, the size of the mill, the ultimate disposition of the water, and other circumstances, and averaging, perhaps, $100; and as they use generally powers of from 20 to 60 horse-power or thereabout, the price may be considered as from $2 to $5 per horse-power. These figures, however, are very rough, no measurements of the water ever having been made. An additional charge is made if the water is allowed to remain in the canal during the winter, as it is usually drawn off at that season of the year.

On the North branch there are three of these mills using water from the canal, viz, a grist-mill at Beach Haven, using the fall of a lock (9.75 feet), a keg factory at Rupert, with a fall of 10 feet, and the pumping machinery at Berwick, which supplies the town with water, with a fall of 7 feet. The water is generally drawn off during the winter. Some data regarding the power available from the canal will be found on page 64.

Just below the junction of the North and West branches of the river is the second canal dam, at Sunbury. It is 2,600 feet long and 7.5 feet high above low water, and its pond is used for navigation for 2½ miles. It supplies no power, though a considerable amount could be used, subject, however, to frequent interruptions. The site is not a very favorable one, on that account, although the volume of water is very large—being, according to my estimates, not less than 4,350 cubic feet per second when at its minimum, and 6,100 during the low season of dry years. The former quantity would correspond to nearly 500 gross horse-power per foot, and the latter to nearly 700. The drainage area above this place is over 17,000 square miles.

There is no power on the river between this dam and the next canal dam, at Clark's Ferry, just above the mouth of the Juniata. This dam is 1,955 feet long and 7 feet high, and backs the water 2 miles. In its pond boats cross the river. The fall could no doubt be used for power, and theoretically a very large amount would be available, the drainage area being about 18,829 square miles. I should judge that the flow during the low season of dry years would be not less than 6,600 cubic feet per second, affording 750 gross horse-power per foot. There would of course be trouble with backwater, and it would probably not be economical to use much power.

Two saw mills use power from the canal between Sunbury and Clark's Ferry, one at Trevorton locks, using a fall of 8 feet, and one at Liverpool lock with a fall of 7 feet.

The next power as the stream is descended is at Conewango (or Conewago) falls, just below the mouth of Conewago creek, and about 5 miles below Middletown. These falls are the most important on the river above Columbia. According to measurements with a pocket-level, the fall amounts to 7 or 8 feet in less than a mile, and I think it probable that by means of a dam a fall of 10 or 12 feet could be utilized at this place. The width of the stream is nearly a quarter of a mile at the head of the falls, and from 800 to 1,000 feet at the foot. The bed is rocky and the banks covered with rocks and bowlders. The facilities for building are not very good on the east side, on account of the canal and the railroad, which follow the bank quite closely, leaving little or no room in times of high water; still the power might be utilized on this side, and, in fact, there was once a canal cut there, serving to let rafts pass the falls, and at the same time supplying power, it is said, to a small saw-mill. No water runs in this canal now, and it is entirely filled with *débris* and the alluvium deposited by the river. The water was turned into it by a short dam at its head, extending across to an island, and not over 300 feet long. By means of several islands in the stream, a large amount of water could easily be turned to either bank without a dam entirely across the river. On the west side there is also a canal, formerly used to supply power to two mills at the lower end and to carry boats by the falls. The fall used was about 8 feet. There was one guard and one outlet lock, and a wing, dam at the head of the canal, now in bad condition, though not entirely carried away. This canal could be cleaned out without much difficulty, and the fall utilized at the lower end; and on the whole the building facilities are better on this side than on the other. The river seldom rises over 8 feet here, it is said, and never runs over into the canal just described. The Northern Central railroad runs close by the bank of the river, so that the facilities for transportation by rail are equally good on either side of the river.

The next power is at Columbia, where we come to the lowest canal dam on the river. The structure is 6,800 feet long and 7½ feet high. Power is available only on the eastern shore, where a small amount is already used for a saw-mill. The power theoretically available is estimated on page 64.

Between Clark's Ferry and Columbia there are a few small mills using power from the canal; one, a saw-mill, just below Clark's Ferry, takes water from the river and uses a fall of from 6 to 8 feet; a grist-mill at Harrisburg uses a fall of 15 feet, feeding to the river; and the canal company has some shops at Harrisburg, with a fall of 11 feet, feeding to the canal.

From Columbia to the mouth of the river there is, according to what has been said on pages 60 and 61, a large amount of power, the fall being large. There are numerous rapids, and numerous places where small mills might be located, but it would seem that the banks are not very favorable for the development of large powers, while the width and swiftness of the river would no doubt render dams very expensive. Besides, the canal on the west and the railroad on the east, both following the river pretty closely, might interfere with the development of some sites. Perhaps the best opportunity for the utilization of power within this distance is afforded at the lower part

near the mouth of the river, where there is a canal 9 miles long, extending from Peach Bottom to a point a mile above Port Deposit, and originally constructed, many years ago, for purposes of navigation, as well as with the object of supplying a certain amount of power. A wing-dam was built at its head, but it is no longer in existence, and the canal is much filled up. The total fall is stated at 80 feet, and there were locks as follows: At the head, a guard-lock with a lift of a few feet; at Conewingo, 3 miles below the head, locks with a total lift of 20 feet; at Octarara, 22 feet; at the "burnt mill", 24 feet; and an outlet-lock, 12 feet. It was intended to use considerable power at each lock, excepting the guard- and outlet-locks, and several small mills were built, but they have not been in operation for many years. The old locks are all gone; but if it were desired to develop power in this vicinity I think that a large amount could easily be rendered available here. It is no doubt the best site in the vicinity for a large power, and in fact the best site on the river. The canal could be made to intercept the waters of a number of streams which now flow into the river, viz, Octarara, Conewingo, and Fishing creeks.

The preceding pages show that the Susquehanna river offers a very small amount of power in comparison with its size, and that there are only four or five sites at all worthy of attention. Passing as it does through the coal-fields, it is not probable that much power will be used on the river for some time to come, especially so long as good small powers can be found on the tributary creeks. The expense of building the long dams which any extensive utilization of power would render necessary, and of maintaining them against the heavy freshets and ice jams of the river, and the small fall available in all except a few places, render the stream of small value for power in comparison with its size. It is, no doubt, more suited for improvement as a channel of communication than as a source of power.

The following table gives a summary of the power available on the stream at the sites specially referred to in the preceding pages. The maximum power available with storage has not been estimated, because of its being practically unavailable. And it must be specially remarked that on account of the great size of the stream even the other powers estimated in the table are not fully available. Although power could be used at each dam, it would manifestly be impracticable to turn even the minimum flow of the stream to either side, except at Binghamton so that from a practical point of view all that can be said is that at each of the sites named above a certain small amount of power can be economically used.

Summary of power on the Susquehanna river.

Locality.	Distance from mouth.	Drainage area.	Rainfall on basin.					Total fall.		Horse-power available, gross. (a)			Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Length.	Height.	Minimum.	Minimum low season.	Low season, dry years.	
	Miles.	*Sq. miles.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Miles.*	*Feet.*				
Binghamton	318	2,279	9	11	10	8	38	....	5.5	215	300	350	Dam 5.5 feet high.
Nanticoke dam	174	9,850	10	11	10	8	39	....	6.0	1,540	1,875	2,250	Dam 6 feet high.
Sunbury dam	122	17,425	10	12	10	8	40	....	7.5	3,700	4,450	5,200	Dam 7.5 feet high.
Clark's Ferry dam	84	18,829	10	12	10	8	40	....	7.0	3,750	4,500	5,250	Dam 7 feet high.
Conewago falls	57	23,860	10	12	10	8	40	....	10.0±	8,100±	9,400	10,800	See description.
Columbia dam	43	24,835	10	12	10	8	40	....	7.5	6,350	7,400	8,450	Dam 7.5 feet high.
Port Deposit canal	5±	26,000	10	12	10	8	40	9	80.0	71,000	82,800	94,600	

a See pages 8 to 11. The utilized power on the stream and its tributaries is tabulated on pages 80 to 89.

In regard to the amount of power available from the Pennsylvania canal, it depends upon whether the water is discharged into the river or into a lower level. As regards the power available at the locks, the chief engineer of the canal, Mr. Thomas T. Wierman, has been to the trouble of having measurements made of the flume-water, or the water flowing around the locks in the flumes, for supplying the lower levels, and he states that on the eastern division of the canal, from Clark's Ferry dam to Columbia, there are 15 lift-locks, with an average lift of 8.6 feet each, and an average flow around the locks of 125 cubic feet per second. This would afford a theoretical or gross power of 14.2 horse-power per foot, or a total of over 1,800 gross horse power. It is said that a large proportion of this could be easily utilized.

It may be as well to give here Mr. Wierman's figures for all the remaining divisions of the canal. On the lower West Branch division, from Northumberland to Clark's Ferry dam, there are 9 lift-locks, with an average lift of 7.1 feet, and an average flow around them of 87 cubic feet per second, affording a total gross power of nearly 650 horse-power. On the Wyoming division, from Nanticoke dam to Northumberland, there are 7 lift-locks, with an average lift of 9 feet, and an average flow of 150 cubic feet per second, affording in all 1,071 gross horse-power. On the upper West Branch division, from Lock Haven to Northumberland, there are 16 locks, averaging 6 feet each, with 66 cubic feet per second, or a total power of 720 gross horse-power. On the Juniata division, from Huntington dam to the Susquehanna, there are 34 lift-locks, with an average lift of 7 feet, and 54 cubic feet per second, or, in all, 1,461 gross horse-power.

The use of these powers does not interfere with the navigation on the canal. Although at each lock the power available is small, there seems to be no reason why it could not in very many cases be easily and advantageously utilized.

TRIBUTARIES OF THE NORTH BRANCH OF THE SUSQUEHANNA RIVER.

A list of the more important tributaries above the Chemung, with their drainage areas, will be found in the table on page 78, and in the table of utilized power will be found a statement of the total power utilized on them. As a rule, they seem to be well improved, and are, doubtless, better suited for power than the main stream. They flow in beds of sand and gravel, with no natural falls; but their declivities, though generally gradual, are steeper than that of the main river, and the falls utilized at the mills are sometimes quite large, the mills being generally saw- and grist-mills, using only small amounts of power. There are lakes on some of these streams, sometimes covering sufficient area to regulate their flow to a considerable extent. Lake Otsego, at the head of the river, is about 7½ miles long, and 1½ mile wide, and Oak creek, the first tributary of any note, rises in Schuyler's lake, a sheet of water nearly 4 miles long and about a mile wide. These are the only large sheets of water, but there are numerous small ones, covering from a few acres to nearly a square mile. Estimates of the flow of these tributaries are scarcely necessary. The Chenango river, the most important of them, drains an area of 1,540 square miles, taking its rise in Madison county, and flowing south through Madison, Chenango, and Broome, and by the towns of Sherburne, Norwich, and Oxford, emptying into the Susquehanna at Binghamton. At this place there is a power which will give an idea of the water-power in the vicinity. A dam at the head of Noyes' island, 1.200 feet long and 3 feet high, built of brush and stone, turns the water to one side, and at the foot of the island, which is 1,300 feet long, a second dam 40 feet long and 5 feet high connects it with the shore, and here the mills are located, comprising a grist-mill, a comb factory, and a brush factory. The privilege is owned by E. M. & J. P. Noyes, who operate the comb factory and rent the other two mills, the fall used being 5 feet at low water. Full capacity can be obtained for about nine months of the year, the power utilized being stated as about 125 (?) horse-power. There is also occasional trouble on account of backwater, the water rising, it is said, to a height of 22 feet in extreme freshets, though not ordinarily above 12 or 14 feet. It is stated that in dry seasons the mills use all the water in the river. Three miles above Binghamton, at Port Dickinson, there is a second power, the fall being about 5 feet, with a dam 550 feet long and 4 or 5 feet high. The power is utilized by a paper-mill, a grist-mill, and a flour-mill, using together some 150 horse-power.(*a*) Full capacity can be obtained during only about ten months. There are numerous small saw- and grist-mills on the main stream and its tributaries, above this point, but none are of importance. The stream is bordered in many places by bottoms subject to overflow.

Owego creek, which joins the Susquehanna just below Owego, draining about 391 square miles, has a number of small mills. Its power is said to be quite well utilized, and with the exception of a mill at the mouth, which has a fall of 16 feet, with a race three-quarters of a mile long, the falls are generally 6 or 8 feet.

Shepard's creek, or Cayuta creek, heading in Cayuta lake, in Schuyler county, though a small stream, draining only about 148 square miles, is utilized to a considerable extent by grist- and saw-mills, a tannery, and a paper-mill. Near the mouth there was a woolen-mill, burned several years ago, but the dam is still there, and the available fall is 12 or 13 feet, with a race half a mile long. Near the mouth is also a flour-mill, with a fall of 12.5 feet at low water, and using, in connection with a plaster-mill, some 80 or 100 horse-power, (?) and with no waste in summer. It is said that there are several unimproved sites on the stream besides that of the old woolen-mill.

The Chemung river, the most important affluent of the North branch, has its sources in Pennsylvania and New York, but the main stream is formed in Steuben county, New York, at the town of Painted Post, by the union of the Tioga and Conhocton rivers, whence it pursues a general southeasterly course, passing into Chemung county, and finally joining the Susquehanna in Bradford county, Pennsylvania, just south of the state line, after having drained a total area of some 2,500 square miles. Measured in a straight line, the length of the stream is about 35 miles, and the only towns of importance by which it flows are Corning, Elmira, and Athens. There was once a canal along the stream, and it is said that there were three canal dams on the river, one at Athens, one at Corning, and one at an intermediate point, but no traces of them are now to be seen. The character of the drainage basin of the stream, which flows with a uniform declivity over a bed of sand and gravel, with no falls and few rapids, resembles that of the Chenango. That part of it lying in Pennsylvania is perhaps rather more broken, and the elevation of the water-shed which forms its boundary is also greater than in New York, attaining to 1,650 or 1,700 feet at the head-waters of the Tioga and Genesee,(*b*) while the elevation of the summit between the Chemung river and Seneca lake is only 890 feet.(*c*) There are a few small lakes in the basin, but they are not large enough to regulate the flow to a great extent, so that the stream is subject to quite heavy freshets, and is considered more variable in flow than the Susquehanna. In March, 1865, the water rose 24 feet at Elmira, and probably higher at other places. Such freshets, together with the ice-jams

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a The power used can not be stated exactly, and this figure may be considerably in error.

b Rogers' *Geology of Pennsylvania*, p. 4.

c *Geology of New York.*

which occur, would be destructive to high dams, but the existing ones, being low brush or crib-work structures, are not often injured. Sheet-piling is sometimes used in their construction, where the bed of the stream is very pervious. The power used on the river is altogether insignificant, there being no rapids with falls of over a few feet, the slope of the stream being not greater than about 4 feet per mile, and there are few available sites not used. A mile below Athens there is a grist-mill with a brush and timber dam 600 feet long and 2 feet high, with a fall of 4 or 5 feet, and utilizing from 25 to 50 horse-power. At Athens there was once a canal dam, said to have been 9 feet high, and backing the water a considerable distance. There is little natural fall in the river, and such sites might be found at a number of places, fall being obtained by backing up the water and overflowing more or less land. At Tozer's bridge, a mile and a half above Athens, there is a small fall available, and several mills were once located there. Several similar sites exist below Elmira, at which place there is a grist-mill, with a fall of 5 feet, and using about 60 horse-power; while above that point there are also a few small rapids, none of any consequence, although power could no doubt be obtained by damming.

The Conhocton river, which rises in Livingston county and flows southeast into Steuben to join the Canisteo at Painted Post, drains an area of about 600 square miles, and is said to be the best stream for power in the neighborhood. The table on page 83 will show that it is used quite extensively for small mills, the falls being generally 8 or 9 feet. Its flow is said to be more steady than that of any other large stream in the vicinity, on account of numerous springs and several small lakes, and the powers are therefore better. The declivity of the stream is uniform, and no sites not used were brought to my notice, although it is probable that some power could be developed by damming in many places. Many of the mills have to stop running during the dry season, or are obliged to run at greatly reduced capacity.

The Tioga river, and its tributary the Canisteo, are similar in general character to the Conhocton, and are utilized by small saw- and grist-mills. They offer no falls or rapids of importance. Their flow is said to be much more variable than formerly, on account of the clearing of the land. The fall of these streams is probably greater than that of the Conhocton, but their declivities are uniform. The banks are higher and the country is more broken, and the mill-ponds are therefore small, and there are no other artificial reservoirs of any kind. The freshets are said to be very violent, and the dams so subject to undermining that they are frequently built on piling. The falls vary from 5 to 10 feet, and the mills generally have from 2 to 4 pairs of stones.

It is evident from the above that the drainage basin of the upper Susquehanna is not favorable for the development of large powers, although a large number of smaller powers may be obtained artificially.

After receiving the Chemung, the Susquehanna passes from the plateau of New York into the real mountain district, and its tributaries have more fall than farther north, or at least they offer better sites for power, having more numerous rapids, and sometimes cataracts, with beds of solid rock. They are utilized to a considerable extent, generally by saw- and grist-mills, but none of them being large streams, they may be dismissed very briefly.

Sugar creek, from the west, is utilized by a number of saw- and grist-mills, the latter with from 2 to 4 pairs of stones. It has no falls, so far as I could learn.

Towanda creek, from the west, is similar, and a few small lakes are tributary to it. Some of the small tributaries of these streams have large falls.

Wysox creek, from the east, runs a few small mills; and Wyalusing creek, from the same side, has been quite well improved, but some sites formerly occupied by saw-mills have been abandoned as the country became cleared. Almost all of the mills in this vicinity are short of water during the summer. The falls average 8 or 9 feet, and the dams are generally of brush or crib-work.

Mehoopany creek, from the west, is a rapid stream, but has no falls, so far as I could learn. It is utilized by a few mills.

Bowman's creek, also from the west, is said to have a fall of 15 feet about 8 miles from its mouth, utilized by a saw-mill with a total fall of 27 feet, the dam being 12 feet high. There is said to be an unimproved site 20 miles from the mouth, but the stream must be very small there. One of its tributaries, Leonard's creek, is said to have a number of natural falls, some unimproved.

Meshoppen creek, from the east, is said to have two falls within 300 feet of each other, a mile and a quarter from the mouth, each of 20 feet, and unimproved. The elevation of the stream at its mouth, according to information furnished by Mr. Robert H. Sayre, chief engineer of the Lehigh Valley railroad, is 610 feet, while at the crossing of the Montrose railroad, 12 miles above, measured on the map, it is 925 feet, according to the engineer, Mr. Ansart; so that the fall is very large within that distance. It is probable that all the streams in this neighborhood have steep declivities.

Tunkhannock creek, from the east, is the largest tributary of the North branch below the Chemung, draining over 400 square miles. Regarding its power, however, I have no particulars except what is contained in the table of utilized power. I heard of no falls on the stream, although it was stated that there were numerous rapids where power could be developed. The stream is utilized only by small mills, with 3 or 4 pairs of stones. There are several small lakes in the drainage basin, the largest being Marcy lake, covering, it is said, 200 acres, and just below the lake, on the outlet leading to the Tunkhannock, a natural fall of 30 feet is reported, not in use,

while on the same stream a fall of some 20 or 25 feet is used by a toy factory, the power being very constant. The elevation of the lake is given as 957 feet by Mr. Ansart, engineer of the Montrose railroad. Fall creek, the outlet of lake Wynola (?), has also some large falls, and it is said that there is a dam at the outlet of the lake. There seem to be a number of small undeveloped powers in this vicinity, and, on account of the lakes, some of them may be valuable.

The Lackawanna river, from the east, enters the Susquehanna at Pittston and drains an area of nearly 325 square miles. Rising in Susquehanna and Wayne counties, it pursues a southerly and southwesterly course, passing into Lackawanna and Luzerne counties and draining a long and narrow basin. It has tributary to it a number of small lakes. Like the other tributaries which have been mentioned, it has some falls and rapids, with a rock bed in places, and is utilized for small mills of various kinds. During the past few years the land has been rapidly cleared in the basin, and great complaint is made that the flow of the stream is much more variable than formerly and that the water-power is of small value. The fact that fuel costs very little in this vicinity has also the effect of diminishing the value of the water-power. The stream is moreover said to be so polluted by the water pumped from the mines that no animal can live in it; and it is said to rapidly corrode cast iron, so that wheels and gates have to be replaced at short intervals. As regards shoals and mills, there is said to be a succession of rapids near the mouth of the stream, with a total fall of some 20 or 30 feet in half a mile, utilized to some extent, but not completely. At Providence, about 12 miles from the mouth, there is an ax factory, with a fall of 10 feet. Above are a number of saw- and grist-mills and a few powder-mills, and the power of the stream or its tributaries is also used to some extent for pumping out mines. Roaring brook and Spring brook, small tributaries of the Lackawanna, are utilized for saw- and grist-mills, but the powers are all small, and, although on the former there are some falls near Scranton, they are of not much value for power.

Harvey's creek, which enters the Susquehanna from the west, just above the Nanticoke dam, is the outlet of Harvey's lake, which is said to cover about a square mile, and is dammed at its outlet by a stone dam 6 feet high. The flow of the stream is thus regulated to a considerable extent, and its power is said to be the best in the vicinity, the fall being quite large and the bed often rock. It is utilized by some 10 or 12 mills, mostly saw-mills.

Hunlock's creek, emptying 4 miles below Nanticoke, from the west, has its source in a pond, partly artificial, and is similar in character to Harvey's creek, except that its flow is not so regular. Near its mouth there is said to be a natural fall of 30 or 40 feet, not utilized, and all the tributaries to the Susquehanna in this immediate neighborhood, where it leaves the Wyoming valley and cuts through the mountains, have very steep declivities, and often rapids and cataracts, over beds of solid rock. The great trouble with most of them is their variable flow. Although quite well utilized, numerous sites may be found on almost all of them.

Shickshinny creek, the next tributary from the west, is like the others, but perhaps even more variable in flow than Hunlock's creek.

Big and Little Wapwallopen creeks, from the east, enter the river below Nanticoke, and resemble the streams just described. The former is very small, and the latter is also a small stream, but has considerable utilized power. About a mile above its mouth it has a large fall, amounting to 200 feet or over in about 2 miles, which is utilized to a considerable extent by Dupont & Co.'s powder-mills. As the stream is ascended we first come to a grist-mill, with a fall of 22 feet, a race a mile long, and a dam 6 feet high; then a powder-mill, with a fall of 36 feet, a flume 300 feet long, and a dam 4 feet high; then another powder-mill, with a fall of 18 feet, a race of 500 feet, and a dam 12 feet high; then another, with a fall of 8 feet, a dam of the same height, and no race; then still others, along a race 3,200 feet long, the fall being 119 feet at its lower end, and the dam 4 feet high; then a fall of 30 feet unimproved, and not very favorable, and, finally, a number of grist- and saw-mills on the upper part of the stream. The power used at the powder-mills aggregates about 275 horse-power, but full capacity can be obtained during only six months. There are said to be few good sites not utilized.

Nescopec creek, which enters the river opposite Berwick, resembles the creek just described, but has not so much fall, though a much larger stream. I heard of no unimproved sites, and none of the mills are large.

Fishing creek, which enters from the west just below Bloomsburg, has its sources in Sullivan county, and flows south into Columbia, draining an area of at least 350 square miles. It is well utilized by grist- and saw-mills, paper-mills, and furnaces, and there are said to be some sites yet unimproved. The falls used are sometimes quite large, the greater part being obtained by damming. The stream is a good one for power, but its flow is quite variable, there being only two or three very small lakes tributary to it.

Catawissa creek, from the east, is the last tributary of the North branch which calls for remark, rising in Schuylkill county and emptying into the river at Catawissa. It has no lakes, and its fall is said to be uniform; yet its flow is said to be tolerably constant. Like the other streams in the vicinity, it is utilized by small mills of various kinds.

As regards the rainfall over the basins of these tributaries, in New York state it is about 36 or 37 inches, of which 9 fall in spring, 10 in summer and in autumn, and 8 in winter. In some parts it is smaller, even as low as 32 or 33 inches. In Pennsylvania it is about 39 or 40 inches—10 in spring, 11 in summer, 11 in autumn, and 8 in winter.

THE WEST BRANCH OF THE SUSQUEHANNA RIVER.

This noble tributary has its sources in the mountains of Cambria county, at an elevation probably not less than that of the sources of the North branch, for the divide between its waters and those of the Allegheny lies at a height of 2,000 feet or more above the sea. Flowing first in a northerly direction, and receiving some tributaries from Indiana county on the west, the stream enters Clearfield county, and gradually bending to the right it flows northeast between Center and Clinton counties, and then east through Clinton into Lycoming, where it bends suddenly to the right again, and flows nearly south between Union and Northumberland to join the North branch at the town of Northumberland. Its total drainage area measures about 6,466 square miles, and it receives a number of important tributaries, a list of which, with their drainage areas, will be found on page 79. The river washes the towns of Clearfield, Lock Haven, Williamsport, Muncy, Milton, Lewisburg, and Northumberland, and is navigable, by means of the canal along its banks, to Lock Haven and beyond, there being four canal dams on the stream, the ponds of which are used for navigation. The character of the stream will be understood from the following quotation from Dr. Rogers' *Geology of Pennsylvania:*

> The upper part of the West branch of the Susquehanna, and also its tributaries, the Sinnemahoning, Kettle creek, Pine creek, etc., draining the high plateau northwest of the Alleghany mountains, flow through deep trenches in the horizontal strata, very analogous in their features to those which give passage to the Delaware and the main or North Susquehanna, in the northeastern part of the state. From the mouth of the Sinnemahoning out into the Bald Eagle valley, the river hills are very high and steep, and admit extremely narrow strips of level ground between their feet and the river, except near the openings of the lateral streams. The trough through which the lower half of Pine creek flows is equally profound. Entering the valley between the Alleghany mountain and the Bald Eagle ridge, the river pursues a beautiful winding course the whole way from Lock Haven to the neighborhood of Muncy, alternately sweeping toward the middle of the cultivated valley and back again, close in to the base of the steep and wood-covered ridge. Near Muncy it turns with a broad majestic curve round the end of the Bald Eagle mountain, and in a few miles deflects from a southwest to a west course, through a highly fertile, richly cultivated open country, till it strikes the base of the Blue Hill, or range of red sandstone cliffs above Northumberland. Southwest of Muncy the river crosses a singular belt of deeply-eroded country, full of conical hills.

The fall of the stream is shown by the following table:

Slope of the West branch of the Susquehanna river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	429			
			7	2	0.29
Lewisburg dam, water below	7	431			
			0	3	....
Lewisburg dam, crest	7	434			
			16	28	1.75
Muncy dam, water below	23	462			
			0	7	....
Muncy dam, crest	23	469			
			16	29	1.81
Williamsport dam, water below	39	498			
			0	10	....
Williamsport dam, crest	39	508			
			26	31	1.19
Lock Haven dam, water below	65	539			
			0	11	....
Lock Haven dam, crest	65	550			
			4	1	0.25
Queen's Run dam, water below	69	551			
			0	6	....
Queen's Run dam, crest	69	557			
			36	138	3.83
Keating	105	695			
			55	422	7.67
Curwinsville	160	1,117			

It will be seen that as far up as Queen's run the fall of the river is small, while above that point, in the true mountain region, it is much larger. Above that point, too, the banks of the stream and of its tributaries are generally high, and there are few low grounds subject to overflow, while below that point the river traverses a wide and fertile valley, without, however, overflowing its banks to any considerable extent. The bed of the stream is generally gravel and sand, with sometimes a rock ledge in the upper parts. The flow is quite variable, but as no gaugings are at hand, exact figures can not be presented, and I am therefore obliged to resort to estimate. On account of the larger proportion of mountain district, and the steeper slopes in the basin we are considering, I should judge the flow to be even more variable than that of the North branch; and this opinion is strengthened by the absence of lakes of importance. But the fact that a great part of the basin is still thickly wooded may have an important effect, perhaps more than compensating for the absence of lakes and the steepness of the slopes. The forests, however, are being rapidly destroyed in many places, and the lumber is being floated down to the main stream from numberless tributaries. The facilities for artificial reservoirs are probably good, and the flow of

many of the tributaries might no doubt be regulated to a considerable extent. The rainfall in the basin is about 38 or 40 inches, with a tolerably uniform distribution, but with less in winter than in any other season. The stream is easily accessible except in the upper part of its course, being followed as far as the mouth of the Sinnemahoning by the Philadelphia and Erie railroad. As it is ascended, the first dam is the canal dam at Lewisburg, 920 feet long and 3 feet high. Its pond is used for navigation for over a mile. The next dam is the Muncy dam, 3 miles below the town of the same name, and which might be used for power, its height being 7 feet and its length 1,020 feet. Its pond is navigated by canal-boats for over 4 miles. The minimum flow of the stream at this point is probably not less than 900 cubic feet per second, but only a small proportion of the total power that this would afford could be used with advantage at the Muncy dam.

The next dam is that at Williamsport. It was built in the years 1867 and 1868 by the Susquehanna Boom Company, to back the water and afford a pond for the booms for collecting the lumber which is floated down the river to this place. The dam is built of crib-work, filled with stone and backed with gravel, and is 1,000 feet long and 10 feet high above low water, with a chute 60 feet wide for the passage of rafts. The power afforded at this place is already utilized by several mills, namely: Noble & Sons' flour-mill, and Taylor & Son's saw-mill, probably using together, however, only a couple of hundred horse-power. The fall used is 8 or 9 feet, and the mills are at times obliged to stop on account of high water or ice. There is no doubt that a considerably greater amount of power than is now used could be advantageously utilized at this place. The drainage area being about 5,300 square miles, it is not probable that the minimum flow will be much less than 800 cubic feet per second, and this would afford, with a fall of 10 feet, a gross power of over 900 horse-power; while at ordinary stages a very much larger amount would be available. The fall, however, is scarcely large enough to warrant the full development of the power.

The Williamsport dam backs the water a number of miles, and the fall of the stream is small all the way to Lock Haven, where we meet the next canal dam. This dam has an overfall of 850 feet, and is 11 feet high above low water. It is not used at all for power, although it could be so used without much difficulty and a considerable amount of power developed. The drainage area is about 3,040 square miles, and the minimum flow probably never less than 400 cubic feet per second, which would afford, with a fall of 10 feet, about 450 gross horse-power, while in ordinary years a very much larger quantity—perhaps double—would be available almost uninterruptedly. This power and the one at Williamsport are the two principal powers on the stream, and in fact the only important ones. Although the falls are not large, and there would be occasional interruption on account of high water, there seems to be no reason why both powers should not be utilized to a considerable extent. The location at Lock Haven and the facilities for races and buildings are good.

The Lock Haven dam backs the water for about 4 miles to the last canal dam on the river, at Queen's run. This dam is 6 feet high above low water, with an overfall of 614 feet, and a raft-chute 31 by 500 feet. Its pool is used for navigation for about 3 miles. No power is utilized at the place, and although some might be developed, the low fall renders the site an unfavorable one. Between this point and the mouth of the Sinnemahoning, although the fall is greater, there are no important powers; neither are there any below Clearfield, so far as I could learn. The declivity of the stream is quite uniform, and although the fall is considerable, there are no rapids of consequence. Power could doubtless be developed at many places by damming, but I can specify few particular sites. At Buttermilk falls, about 20 miles above Keating (at the mouth of the Sinnemahoning), the fall is 6 feet in about 2,000 feet; and there are a few other rapids of similar character. I am indebted to Mr. Edwin H. Welch, civil engineer, for a profile of the stream from Keating to the mouth of Moshannon creek, a distance of 25¼ miles, from which it appears that the average fall in that distance is 6.57 feet per mile, the greatest fall in a mile being in the first mile above Keating, viz, 16 feet; while at several places there are falls of 9 or 10 feet in a mile. There are, however, no specially fine sites for power, and little if any power is utilized on the stream below Clearfield. Above that point there are a number of small saw- and grist-mills run by the stream, the latter generally with two or three pairs of stones. Power would probably be utilized below Clearfield were it not that the river is very inaccessible. The table of utilized power gives all the additional data I have regarding the stream.

The flow of the upper part of the Susquehanna, as well as of its smaller tributaries, is modified to some extent by the operations of the lumbermen. On most of these streams "splash-dams" are built, ponding the water sometimes over considerable areas, and serving to hold the logs which are sent down, until a sufficient number have been collected, when the gates in the dams are raised, letting the water out suddenly, so that the logs are carried down on the swell or wave to the next dam or to the main river, where the natural current is sufficient to carry them along. These artificial reservoirs, although now of no benefit to the water-power of the stream, being in fact rather the contrary, could be utilized as storage reservoirs to regulate the flow. Their effect on the water-power of the streams is probably small at present, as the flushing of the logs does not occur at the time when the streams are lowest; in fact, some mill ponds are even used for the same purpose. Their effect on the larger tributaries or on the main stream is, of course, too small to be noticed. Regarding the size of the reservoirs formed I could obtain no accurate information, but probably few cover over 100 acres. The dams are almost always of crib-work, and the sites are chosen with a view of overflowing as much land as possible.

Before leaving the West branch of the Susquehanna, attention must be called to the statements on page 64 regarding the power available from the canal. At present very little power is utilized from this source, there being only one small grist-mill using water from the canal, with a head and fall of 11 (?) feet and 20 or 30 horse-power.

THE TRIBUTARIES OF THE WEST BRANCH OF THE SUSQUEHANNA RIVER.

The water-power of the tributaries of the West branch of the Susquehanna is at present of little importance. That utilized is altogether insignificant; that potential, although theoretically large, is practically not very available, partly because many of the streams are very inaccessible, draining a wild and very little developed country, and partly because they flow with uniform declivities over beds of drift, offering few precipitous falls and few powers likely to be of any but local interest or value. The information that I could collect regarding these streams is very meager. Most of them are used for rafting or logging much more than for power, and their utilized power is very small. On account of their uniform slope I could learn of but few sites for power not used, and can say little regarding the facilities for the development of power. It may be presumed, however, that they are tolerably good. The flow of the streams is subject to considerable fluctuations, but I could not learn that the freshets are specially violent. Muncy creek, the first important tributary encountered as the river is ascended, rises in Sullivan county and flows southwest into Lycoming. It has three splash-dams and several lakes tributary to it, all of small extent. Loyalsock creek, which empties at Williamsport, is a much larger stream, also with several small lakes tributary to it. On some of its small tributaries there are said to be precipitous falls, but they are almost valueless for power. There are ten or a dozen splash-dams on the stream and its tributaries, and a number of saw-mills. Lycoming creek is a similar stream. It has a nail factory near its mouth, besides saw- and grist-mills. Twenty miles from its mouth there is a site not utilized, formerly used by a mill, with a fall, it is said, of 15 feet; and just above this is another similar site. Pine creek, the largest tributary below the Sinnemahoning, is similar to those already mentioned, but I have no details regarding its power. Just below Lock Haven a stream comes in from the south which is perhaps the best water-power stream in the vicinity, viz, Bald Eagle creek. It rises in the southern part of Centre county and pursues a northeasterly course into Clinton county, its length being about 45 miles, measured in a straight line, and its drainage area about 725 square miles. It receives as tributaries Beech, Fishing, and Spring creeks, all good water-power streams. The value of the stream arises from its constant flow, for, although there are no lakes in the basin, the stream is fed by springs to a large extent, and is said to vary less in flow than any stream in the neighborhood, though I know of no measurements regarding this point. Especially is this true regarding Spring creek, which is said to flow remarkably well in dry weather. All of these streams have beds generally of gravel, with some rock in place. They are not subject to very violent freshets, and their slope is quite large, though generally gradual. Bald Eagle and Spring creeks are quite accessible from the Bald Eagle Valley railroad. The first dam on the Bald Eagle creek is about 3 miles above Lock Haven and above the mouth of Fishing creek. It is a canal dam, used for feeding the branch canal extending from Lock Haven to this place, and used as a feeder of the main West Branch canal. It is 314 feet long, 5 or 6 feet high, and backs the water about 2 miles. On this branch canal there are two mills—a grist-mill at Flemington, feeding to a lower level, and using a fall of 10 feet and about 75 (?) horse-power, and a paper-mill near Lock Haven, with about the same fall and power, it is said. These mills have a full supply of water all the year, the water remaining in the canal during the winter.

Above this canal dam there are several grist-mills on the stream, and at Howard there are the Howard iron works, consisting of a forge and rolling-mill, with a fall of 6½ feet and about 60 (?) horse-power.(a) Full capacity can be obtained during only about ten months. At Rowland there are two powers, owned by Curtins & Co.; the upper one a rolling-mill, with a fall of 7 feet, the dam being 200 feet long and 2½ feet high, and the lower one a grist-mill, furnace, and forge, with a fall of 12 feet. These powers are below the mouth of Spring creek. Above this point there are several small grist-mills, but no large powers. It will be seen that there are no large falls on Bald Eagle creek, and there are said to be no powers not utilized.

The tributaries of Bald Eagle creek are also utilized to a considerable extent by small mills, and their fall is greater than that of the main stream. On Fishing creek, besides a number of grist-mills, there are two ax factories and a woolen-mill, but the powers are small.

Spring creek, which has already been referred to, enters the Bald Eagle at Milesburg, at which place there is a fall of 8 feet, used to run a grist-mill, saw-mill, ax factory, foundery, and machine-shop. Above, there are various mills, specified in the table of utilized power. I learned of several unimproved sites on the stream, near Bellefonte. The first is that of the Bellefonte Car Manufacturing Company, and was formerly used to the extent of about 100 horse-power. The dam is partly of earth and partly of crib-work, and is 300 or 400 feet long, while its height varies from 10 to 12 feet. The fall used was 12 or 14 feet, and it is expected that work will soon be resumed. Just above this power is a paper-mill, not now running, with a fall of 10 feet, and farther up is an ax factory with a fall of 18 feet, not used "on account of expense of hauling". Logan branch, a tributary of Spring creek, just above Bellefonte, is very constant and has a very rapid fall. It runs various mills, and has several sites not used.

a The power is stated at 150 horse-power in the returns of the enumerators. It was returned to me as 60.

The remaining tributaries of the Susquehanna resemble those below Fishing creek from the north. They are more variable in flow than Spring creek, and are utilized only for saw- and grist-mills, with now and then a woolen-mill. Many of them have splash-dams, and are used extensively for logging. Such are Young Woman's creek, Paddy's run, and Kettle creek. Sinnemahoning creek, the largest of all, is little utilized, but I heard of no good sites not used, though at Moccasin falls, below Driftwood, there is said to be a fall of 5 feet or so in 200 feet. I have no further data regarding its numerous tributaries, but they are not very reliable streams, and afford only small powers. Of the tributaries above Sinnemahoning, Mosquito creek is quite a large stream, said to be the most constant in the neighborhood. It has 7 splash-dams and a few mills. Moshannon creek and Clearfield creek are similar streams. On all of the streams in this vicinity power could be developed at many places, and abandoned sites, formerly used for saw-mills, are often met with, but the whole region is almost a wilderness.

THE TRIBUTARIES OF THE SUSQUEHANNA BELOW NORTHUMBERLAND.—The water-power of the affluents of the Susquehanna between the mouth of the West branch and that of the Juniata is not of great importance, although there are numerous sites for small mills. Their fall is quite rapid and their flow very variable. They are utilized only by small saw- and grist-mills. Shamokin creek, which enters from the east below Sunbury, drains 165 square miles, and has several mills averaging each about three pairs of stones. Penn's creek, from the west, is a much larger stream, and has its sources in Centre county, whence it flows east through Union and Snyder. Its declivity is unbroken by falls, though there are numerous ripples, and some good sites where power could be developed. The flow is said to be very steady and the power excellent. There are a number of saw- and grist-mills in operation, the grist-mills near the mouth averaging four pairs of stones, and seldom suffering much from want of water. The falls are not large, averaging only 8 or 10 feet, and obtained by damming. Middle and West Mahontongo creeks, from the west, as well as Mahanoy, Wiconisco, Armstrong's, Powell's, and Clark's creeks, from the east, are small streams. It is said that the power of Wiconisco creek is being injured by coal-dirt filling the creek, and also by the impure water pumped from the coal-mines.

THE JUNIATA RIVER.

This great tributary has its sources far to the west, in Bedford, Blair, and Somerset counties, at a general elevation of some 2,000 feet above the sea, though the divide between its waters and those of the Ohio attains in places a height of nearly 2,800 feet. The stream is described as follows by Dr. Rogers, in his *Geology of Pennsylvania:*

> This second great tributary of the Susquehanna has two chief upper divisions, the Frankstown and the Raystown branches, both of which, like the main stream below their junction, traverse much beautiful scenery. We will trace the Frankstown branch as that which is most accessible. After gathering its head-waters from the eastern slope and the foot-hills of the Alleghany mountains, it begins to assume the volume of a small river near Frankstown. Below this point it first passes the cove of the Lock mountain, a curious district of conical hills, in structure very like the Muncy hills of the West branch. Its course is now by a wild and rocky gorge, through the Lock or Canoe mountain, into Canoe valley. Winding northeastward through this valley it next goes through Tussey mountain into Hartslog valley by an interesting curving pass of the form of the letter S. The mountain, which consists of two ridges, is trenched along its center for the passage of the river, and the Western ridge is moreover breached at Water Street by a lateral notch, which gives passage to a small tributary stream, and heightens much the picturesqueness of the place, which is further enhanced by a great stone-slide covering the ends of the mountain. Crossing Hartslog valley, it next traverses Warrior ridge, passing by the Pulpit rocks. Emerging from the Warrior ridge, and deflecting more toward the east, it crosses the Huntingdon valley and passes by the northern end or knob of Terrace mountain or Sideling hill, receiving first the Raystown branch, which nearly doubles the volume of its waters. Here bending southward it follows a picturesque gap through Stone ridge, and, turning more eastward, it presently enters the deep cleft in Jack's mountain, called "Jack's Narrows", upon the western side of which the mountain is covered with a great stone-slide, or field of naked angular blocks of sandstone, which imparts a most desolate aspect to the pass, especially when the forest is not in leaf. On emerging from Jack's narrows the river crosses a succession of open valleys divided by narrow ridges, until it meets the base of Blue ridge in Sugar valley. There it makes a great loop, turning in an ox-bow backward till it reaches Newton Hamilton, whence it flows with many large sinuosities, longitudinally, through the Juniata or Lewistown valley, to the deep synclinal ravine called the "Long Narrows", formed by the near approach of the Blue and Shade mountains. The "Long Narrows" of the Juniata is a narrow trough between mountain ridges, deeply trenched on their flanks, and thickly clothed with timber on their lower slopes and at their base, and overspread nearer their summits with extensive sloping sheets of dark-gray angular blocks. The pass is 7 miles long, and is one of the wildest and most impressive within the mountains. At the eastern end of the Long narrows the river turns southeastward, and winds between hills and valleys across the country to the base of the Tuscarora mountain, passing Mifflintown, Mexico, and other villages. Below New Mexico it sweeps the base of the Tuscarora mountain for several miles, until it turns abruptly across its eastern end a mile northwest of Millerstown. Below Millerstown the river crosses the Wildcat and Buffalo valleys, washing the end of the Buffalo mountain. Pursuing its course, the Juniata, after making two or three bends, goes through a belt of hills called the "Half-fall Mountain", where, as at nearly all its passes through the larger sandstone ridges, it is impeded by ledges of hard strata and thrown into ripples or rapids. From the Half-fall rapids it flows between steep but low cliffs and hills for about 4 miles farther, to its entrance into the main Susquehanna, at Duncan's island, having followed a winding course entirely across the central zone of the Appalachian chain, through a distance of nearly 200 miles.

The Frankstown branch, rising in Bedford county, flows northeast into Blair and Huntingdon, bending then to the southeast, and receiving the Raystown branch, which rises in Bedford and Somerset counties, and flows northeast into Huntingdon. From their junction the course of the stream lies through Huntingdon, Mifflin, Juniata, and Perry counties, and by the towns of Mount Union, Lewistown, Mifflintown, Millersburg, and others. The total drainage area measures about 3,223 miles. The valley of the main river, as will be understood from Dr.

Rogers' description, is very narrow and the banks are generally high, and the stream has a number of large tributaries, a list of which is given on pages 79 and 80. The bed is generally gravel and sand, often with rock at a very small depth, and sometimes at the surface. The declivity of the stream will be seen from the following table:

Slope of the Juniata river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	336			
			16	44	2.7
Millerstown dam, water below	16	380			
			0	8	....
Millerstown dam, crest	16	388			
			28	54	1.9
Lewistown dam, water below	44	442			
			0	8	....
Lewistown dam, crest	44	450			
			24	62	2.6
Newton Hamilton dam, water below	68	512			
			0	8	....
Newton Hamilton dam, crest	68	520			
			22	90	4.1
Huntingdon dam, water below	90	610±			
			0	12	....
Huntingdon dam, crest	90	622±			

Some elevations along the Frankstown branch above Huntingdon are given on page 75. Between Newton Hamilton and Huntingdon there is one dam, at the mouth of the Raystown branch, but its elevation is not known. The dams referred to are all canal dams, for feeding the canal which extends up the river to Huntingdon, following the stream closely for the entire distance. When it is added that the Pennsylvania railroad follows the main river, the Frankstown branch, and the Little Juniata, a tributary of the latter, almost to the summit of the mountains, it will be seen that the facilities for transportation can not be surpassed.

Regarding the flow of the stream no data could be obtained. There are no lakes to regulate it, and the drainage area is composed largely of parallel valleys drained by the tributaries of the river. The whole basin of the river is comprised in the region of corrugations, and just that part of the region where the parallelism of the ranges is most marked, so that it is traversed from southwest to northeast by a number of parallel ranges, across and between which the river winds, and from the valleys between which it receives its tributaries. The rainfall is about 40 inches—11 in spring, 12 in summer, 9 in autumn, and 8 in winter—a distribution not very unfavorable for constancy of flow; and the basin is quite well wooded, so that possibly the flow may be more uniform than one would suppose, judging from the topography. No reliable data regarding the extreme rises in freshets could be obtained, but there are few low grounds to be overflowed. The facilities for artificial storage are good, and on the tributary creeks numerous sites for reservoirs could be found. With the exception of one on the Frankstown branch, near Hollidaysburg, none exist at present, excepting mill-ponds.

As the table of utilized power given on pages 86 and 87 shows, there is very little manufacturing in the basin of the Juniata, and below the mouth of the Raystown branch there is not a mill of importance on the main stream. A number of grist- and saw-mills on the tributaries, with occasionally a mill of some other kind, make up all that there are in the basin. The reason for this is not to be sought in the absence of any water-power, but in the fact that this is not a manufacturing region, and that the small powers which it offers (for it offers no large ones) are not able to compete with those which have the advantage of being located nearer to the markets. As on the Susquehanna, there is a little power used from the canal on the Juniata, there being three mills run in this way, viz, a saw-mill at Mill creek, discharging to the river, with a fall of 10 feet; a planing-mill at Huntingdon, discharging to a lower level, and a grist-mill at Newport, discharging to the river with a fall of 15 feet. There seems to be no reason why a large amount of power could not be utilized in this way, especially at the locks, where there is generally considerable water wasting, and particularly as the traffic on the canal is quite small and the interests of navigation are less important than on the Susquehanna. (See p. 64.)

As the river is ascended there are several ripples where power could be developed, before we come to the first canal dam, 3 miles below Millerstown. This structure, like all the others on the Juniata and Susquehanna rivers, is built of crib-work, its length being 857 feet and its height 7.5 feet. It ponds the water for 4 miles, and the pond is used for navigation. A certain amount of power could no doubt be utilized at this dam, depending on the amount of water required by the canal, and an estimate of the amount available, using the total flow of the stream, will be found on page 76. Whether the facilities for building are of the best, I am not able to state.

At Lewistown dam, the next on the river, and situated 2.5 miles below the town of Lewistown, the facilities for building are not very good. The dam is located in the Long narrows, and the banks are high on both sides, while on the south the railroad and on the north the canal leave little room for building. The place could be used if

desired, but is not favorable. The north side offers the best location, but the canal would have to be diverted to leave room enough between it and the river. The dam is 412 feet long and 8 feet high, and is used only as a feeder, its pool not being navigated.

Passing over some small ripples, the next power is at Newton Hamilton dam, just below the town of the same name. It is 830 feet long and 8 feet high, and is used only as a feeder. The power theoretically available is estimated on page 76, but I am not able to state whether much could be economically utilized.

Between this dam and the next, at the mouth of the Raystown branch, there are some ripples which have been spoken of as worth developing, especially one near Mount Union, where, on account of a bend in the stream, it is said that a fall of some 20 feet (?) could be obtained with a race of a mile. I do not know who is authority for this statement, but from measurements with a pocket-level, by means of which I obtained the elevation of the canal above the river at its crossings above and below Mount Union, 2 or 3 miles apart, I think it is exaggerated, and that the fall can not be over 10 or 15 feet between the two aqueducts.

The Raystown dam, just below the junction of the two forks of the river, is a crib dam, like all the others, and is 350 feet long and 7.5 feet high; it is used only as a feeder. The power theoretically available may be found estimated on page 76. The facilities for the utilization of this power are said to be good, and the entire flow of both branches, except the small amount needed for the canal, could be rendered available.

Let us now retrace our steps to the mouth of the river, and consider the tributaries in their order ascending the stream. Under this head will then be considered the Raystown and Frankstown branches.

The tributaries of the Juniata offer few or no precipitous falls, and perhaps fewer rapids than the main river, except in cases where they themselves cut through the ranges from one valley to an adjacent one, as is sometimes the case. Their banks vary in height, and sometimes the streams overflow considerable areas of bottom-land, although this is not generally the case. Their flow is quite variable, and the mills utilizing their power, although all small, are sometimes short of water in dry seasons. On only one or two of the tributaries did I hear of there being splash-dams. All the timber which is cut is sawed near by, and not floated down the river to any central point.

There are no lakes of any consequence on these tributaries, and no artificial reservoirs. As the map will show, they are often inaccessible.

Buffalo creek, from the south, and Cocalamus creek, from the north, in Perry county, are small streams utilized by saw- and grist-mills. Tuscarora creek, from the south, is a much larger stream, rising in Huntingdon county, and flowing northeast into Juniata. Besides a few mill-dams, it is said that there are a few splash-dams on the stream. Lost and Jack's creeks, from the north, are small and unimportant streams. Kishacoquillas creek, also from the north, emptying at Lewistown, is the most important stream thus far. It has two branches, one of which flows northeast and the other southwest, uniting near Reedsville to cut through a gap in Jack's mountain, flowing from that point southeast into the Juniata. Besides a number of saw- and grist-mills, there are several mills of other kinds on the stream and its tributaries—a woolen-mill at Milroy, and several others in the neighborhood, an ax factory near Reedsville, on the main stream, with a fall of 16 feet, another near Yeagertown, with a fall of 10 feet, and the works of the Logan Iron & Steel Works, at Logan, on the main stream, with a fall of 13 feet, and using, it is said, 100 horse-power or more, together with other mills, a tannery, foundery, etc. The grist-mills average 3 pairs of stones, and the flow of the stream is said to be tolerably uniform. Near the mouth is a grist- and flour-mill with 4 pairs of stones. There are several sites now idle which were formerly used by saw-mills when lumbering was carried on more extensively. There being no precipitous falls on the main tributaries, I could obtain but little information regarding sites not used, but I learned of the following sites on Kishacoquillas creek: at Lewistown there is a grist-mill, not in operation, with a dam of crib-work, 200 feet long and 9 feet high, a race three-quarters of a mile long, a fall of 15 feet, and a gross power of probably 80 or 100 horse-power in the low season of ordinary years. The mill ran 10 pairs of stones. Between Lewistown and Logan it is said that a fall of 10 feet could be obtained; between the two ax factories named above a fall of 10 feet is claimed; and near Reedsville several sites are claimed, one of 15 or 16 feet on Laurel run. On these little secondary tributary streams there are more frequently large falls, but the powers are very small.

Great Aughwick creek, the largest tributary of the main Juniata below the forks, drains an area of about 316 square miles, comprised in Fulton and Huntingdon counties. This stream probably resembles the others which have been described. Its utilized power, however, is small, and I was unable to obtain any information regarding sites not used, although there are several, including one near the mouth, where mills were formerly located. Though the stream is of considerable size near its mouth, it is soon divided among a number of small tributaries.

The Raystown branch of the Juniata, which drains an area only a few square miles smaller than that drained by the other branch, has its sources in Bedford and Somerset counties, as already mentioned. Its drainage area measures about 909 square miles, and comprises much rolling and farming country. The stream pursues a very tortuous course in a general northeasterly direction, receiving many tributaries of small size, and flowing by the towns of Bedford and Hopewell; but its slope is generally large, as the following approximate table of declivity shows:

Slope of the Raystown branch of the Juniata river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	595			
			40	242	6.0
Near Saxton	40	837			
			13	54	4.2
Piper's run	53	891			
			26	125	4.8
Mount Dallas	79	1,016			

For the elevations in the above table I am indebted to B. Andrew Knight, esq., president of the Huntingdon and Broad Top Mountain Railroad Company. The distances were measured from a map. I was unable to obtain much information regarding the power of the stream, but its slope seems to be very gradual, with no falls and few rapids; and although power could be obtained at many places by damming, there seem to be no very favorable sites. The lower part of the stream is especially tortuous and the banks high, and possibly some sites might be found here where power could be obtained; but at present there is little power used on the stream, and a number of steam flour-mills are in operation in various parts of the basin. The bed is generally gravel, there are no lakes, and the stream is subject to considerable freshets and ice-jams. Several sites may be mentioned where formerly mills were located, among them one at Hopewell where there was once a furnace. On the whole, however, the stream can not be said to be very favorable for water-power. Regarding its flow no data could be obtained. Some of its tributaries have rapids and falls, and the table on page 87 will show that they are utilized to a very much greater extent than the main stream. On Yellow creek, a tributary entering from the west at Hopewell, there is said to be a good unimproved power at the point where it cuts through Tussey's mountain, but the stream is very small.

The Frankstown branch, which is more accessible than the Raystown branch, is also more important as a water-power stream. Its sources are in Bedford and Blair counties, and it flows by the towns of Hollidaysburg, Williamsburg, and Alexandria. It drains an area of about 933 square miles, and its basin is perhaps rather more hilly and mountainous than that of the other branch. The stream was formerly navigable, by means of locks, dams, and canals, as far as the town of Hollidaysburg, but the works above Huntingdon were abandoned for purposes of navigation 8 or 10 years ago, and the dams have partly gone to pieces, so that the Huntingdon dam, a couple of miles above Huntingdon, is now the last navigation work on the Juniata. The dam at the mouth of the Raystown branch backs the water nearly up to the town, and has been described on page 73. The first power on the Frankstown branch is at Huntingdon, where a grist-mill, plaster-mill, and saw-mill use a fall of about 10 feet, by means of two crib-dams extending from the banks to an island, one to its head, the other to its foot. The upper is 6 feet in height, and the lower 10 (?) feet; the race is a mile long, and the power utilized is probably in the neighborhood of 100 horse-power. That available is estimated on page 76. It is said that there is never lack of water.

The next power on the stream is at the Huntingdon dam (2 miles above Huntingdon), which is a crib-work structure 382 feet long and 11.5 feet high, backing the water a mile and a half with an average width of about 400 feet. No power is used at the dam, although it may be said that the total flow here is available, the canal to be used as a race; for no boats go above Huntingdon, and there is no reason why the whole discharge of the stream could not be diverted into the canal, and, with the exception of the small amount necessary for feeding the levels below, used for power at some point along the canal. A portion is so used at present, for between Huntingdon and the dam there is a lock, where the Cottage Planing Mills use a power of about 40 horse-power, with a fall of 8 feet, discharging into the canal below. During the winter they keep the water in the canal above at their own expense. The available power at the dam, taking the fall as 11½ feet, is estimated on page 76. There is very little available fall between it and the grist-mill dam at Huntingdon.

The next power is at the site of the old canal dam known as Piper's dam. Before describing it, however, it will be well to give a list of all the old dams, with their heights and elevations, copied from a profile in the office of the canal company at Harrisburg. As the elevations above tide are not given, I have calculated them, assuming that of the Huntingdon dam as 622 feet, which is probably not more than a few feet from the truth:

Profile of Frankstown branch of the Juniata river.

Locality.	Distance from Huntingdon.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.	DIMENSIONS OF DAM.	
						Length.	Height.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Huntingdon dam, crest	0	622				382	11.5
			2.5	6.0	2.4		
Piper's dam, water below	2.5	626				475	8.0
			0	8.0	....		
Piper's dam, crest	2.5	636					
			1.6	5.0	3.1		
Petersburg dam, water below	4.1	641				300	6.5
			0	6.5	....		
Petersburg dam, crest	4.1	648					
			5.9	45.0	7.6		
Big Water Street dam, water below	10.0	693				283	19.3
			0	19.3	....		
Big Water Street dam, crest	10.0	712					
			2.4	2.0	0.8		
Little Water Street dam, water below	12.4	714				213	12.0
			0	12.0	....		
Little Water Street dam, crest	12.4	726					
			2.0	2.0	1.0		
Willow dam, water below	14.4	728				281	13.0
			0	13.0	....		
Willow dam, crest	14.4	741					
			2.6	29.0	11.2		
Donnelly's dam, water below	17.0	770				220	14.0
			0	14.0	....		
Donnelly's dam, crest	17.0	784					
			1.7	3.0	1.7		
Smoker's dam, water below	18.7	787				182	12.0
			0	12.0	....		
Smoker's dam, crest	18.7	799					
			1.4	1.0	0.7		
Mud dam, water below	20.1	800				180	7.5
			0	7.5	....		
Mud dam, crest	20.1	808					
			2.9	23.0	7.9		
Williamsburg dam, water below	23.0	831				210	10.0
			0	10.0	....		
Williamsburg dam, crest	23.0	839					
			1.1	0.0	0.0		
Three-Mile dam, water below	24.1	839				390	17.5
			0	17.5	....		
Three-Mile dam, crest	24.1	856					
			3.1	0.0	0.0		
Crooked dam, water below	27.2	856				200	10.0
			0	10.0	....		
Crooked dam, crest	27.2	866					
			6.3	29.0	4.6		
Frankstown dam, water below	33.5	895				216	3.5
			0	3.5	....		
Frankstown dam, crest	33.5	899					
			2.9	24.0	8.3		
Hollidaysburg dam, water below	36.4	923				152	4.5
			0	4.5	....		
Hollidaysburg dam, crest	36.4	927					

At two of these dams mills were in operation when the canal was abandoned.

Above Huntingdon dam, then, the next power is at the site of Piper's dam, now destroyed. The old canal led from this dam into the pool of the dam below, with two outlet locks at its lower end, and only about 2 miles above the Huntingdon dam; and it is said on good authority that by using the fall of these outlet locks, the best power in the vicinity could be obtained, with a fall of 14 feet. The power is estimated on page 76. The Petersburg dam is now used to supply power to a grist- and saw-mill at Petersburg, the fall being 8 feet, and about 20 horse-power being used; and formerly there were rolling-mills at the same place. This dam is just below the mouth of Shaver's creek.

Between the Petersburg dam and Big Water Street dam there is considerable fall, and the latter dam, which is now entirely gone with the exception of the abutments, was over 19 feet high. The power is said to be an excellent one, and, by rebuilding the old canal, a fall of over 20 feet could be obtained at Alexandria. It is also stated on good authority that at almost all of the other sites good powers could be developed by rebuilding the dams, and without doing much damage by flowage. It will be seen from the table that between Huntingdon dam and Hollidaysburg the stream has an average fall of 8.3 feet per mile. A large amount of power is therefore theoretically available, and there seems to be no reason why a large proportion could not be utilized. The Williamsburg dam is still standing and in good condition. It is a mile or so above the town, and between the two there is a lock with a lift of 8 feet, so that at Williamsburg a fall of some 15 feet or more could be obtained.

Three-Mile dam is also said to afford a good power, and also the dams above. The abutments and old locks are still in existence, although the dams have been more or less destroyed.

Two miles above Hollidaysburg there is an artificial reservoir, formerly used a feeder for the canal—the only one on the Juniata. It has an area of about 600 acres and a depth of 20 feet, and is formed by a dam 850 feet long and 30 feet high, built mainly of earth, faced with stone, and constructed about the year 1846. The water is discharged through four 30-inch iron pipes. The bed of the stream is rock. A small amount of power could be used here, with a fall of 20 feet, and the reservoir is large enough to hold several months' flow of the stream, so

that it might be made to serve a very useful purpose in regulating—though only to a small extent—the flow of the stream below. It may be mentioned that on the Conemaugh river, on the other side of the mountains, there was formerly a length of 100 miles of canal, now abandoned, and that near Willmore's station there was a larger reservoir than that at Hollidaysburg, called the "Western reservoir".

Notwithstanding the considerable amount of power which seems to be available on the Frankstown branch, but little is used, as the table on page 87 shows.

Of the tributaries of the Frankstown branch, Standing Stone creek, which empties at Huntingdon, has a few mills and some unimproved powers, but they do not seem to be important. Shaver's creek is similar in character. The Little Juniata, which rises in Blair county, near Juniata gap, and flows first northeast as far as the town of Tyrone, where it bends to the right and flows in a southeasterly direction, joining the main stream about a mile above Petersburg, is the most important tributary of the Frankstown branch. It drains an area of about 327 square miles, and is followed for its entire length by the Pennsylvania railroad, so that every point is easily accessible. Its drainage basin is mountainous, and its fall rapid, so that although its flow is quite variable and its freshets are heavy, it does not rise very high. The fall is uniform, and very little power is used on the stream, although there are numerous sites where it could be developed. The first mill is just above Petersburg, near the mouth, the dam being about 9 feet high, and the fall used 11 feet. The mill is a grist-mill, with probably 40 or 50 horse-power. At Barree there are a furnace, a forge, a saw-mill, and a grist-mill, with a fall of 13 feet. Above Tyrone, where the drainage area is about 154 square miles, there is no power of importance used, except about a mile above the town, where the Pennsylvania Axe Company is putting up two dams across the stream, intending to connect the races and utilize a fall of 11 feet, formerly used by a forge. Of sites not used I can only mention as once utilized those at Tyrone forges, and at the site of an old forge just below Tyrone. Other and perhaps better sites could no doubt be found.

None of the tributaries of the Little Juniata are worthy of special mention, though some have large falls.

The following table gives a summary of the power at various places referred to in the previous pages, based, of course, on estimates:

Locality.	Drainage area.	Rainfall.					Fall.	Horse-power available, gross. (a)				Remarks.
		Spring.	Summer.	Autumn.	Winter.	Year.		Minimum.	Minimum low season.	Maximum with storage.	Low season, dry year.	
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*					
Millerstown dam	2,990	11	12	10	8	41	7.5	300	450	1,500	525	Dam 7.5 feet high.
Lewistown dam	2,550	11	12	10	8	41	8.0	275	400	1,400	480	Dam 8 feet high.
Newton Hamilton dam	2,270	11	12	10	8	41	8.0	250	375	1,250	440	Dam 8 feet high.
Raystown dam	1,842	11	12	10	8	41	7.5	200	300	1,000	350	Dam 7.5 feet high.
Huntingdon	770	11	12	10	8	41	10.0	100	150	750	175	Race 1 mile long.
Huntingdon dam	759	11	12	10	8	41	11.5	115	160	875	190	Dam 11.5 feet high.
Piper's dam (outlet locks)	750	11	12	10	8	41	14.0	140	210	1,075	250	
Petersburg dam	750	11	12	10	8	41	6.5	65	100	500	115	Dam 6.5 feet high.
Big Water Street dam	356	11	12	10	8	41	19.3	90	130	700	150	

a See pages 8 to 11.

These figures are not of very much value, but they serve to give an idea of the amounts of power which could be developed at the places named. The table of drainage areas on pages 78 to 80 will enable any one who is acquainted with the country, and has studied the remarks on flow in this report and that on the southern Atlantic water-shed, to estimate intelligently for himself. The tributaries of the Juniata being so little used, it is scarcely necessary to give estimates for them.

The first tributary of the Susquehanna below the Juniata is the Little Juniata, a small stream and of no importance. The next is Sherman's creek, which also enters from the west, and traverses the entire length of Perry county from west to east. It is similar in character to the lower tributaries of the Juniata, and has no powers of much importance. Stony creek, from the east, is a small stream draining a narrow valley, and, although over 20 miles long, has scarcely a tributary. Conedogwinet creek, from the west, is a considerable stream, rising in Franklin county, and passing through Cumberland in an easterly direction, emptying 2 miles above Harrisburg. It drains a region rather more open and less mountainous than that along the Juniata, and its course is very tortuous. It is extensively used for power, chiefly for grist-mills, and no important unimproved sites were spoken of. The most important utilized power is at the mouth, where a crib-work dam 300 feet long and 8 feet high supplies power to a nail factory and rolling-mill, using a fall of 8 feet and 200 horse-power or over, which, however, can be obtained during only eight months. In the summer there is no waste, and the water is probably drawn down in the pond. The bed of the stream is said to consist of ledges of rock at this place and at many places above, and the banks are generally high and not favorable for large reservoirs. All the good sites on the stream are said to be occupied.

Yellow Breeches creek, which rises in the western part of Cumberland county, and in the lower part of its course forms the boundary line between that county and York, is a similar stream. Its fall is quite large, and it is utilized by a number of mills, but none are of importance. The stream and its tributaries are considered good water-power streams, and their flow is said to be not very variable. No good sites, it is said, remain unoccupied, except on some of the small tributaries. Mountain creek, one of them, is used at Laurel Forge in various ways by the South Mountain Iron Company, there being two falls, one of 24 and one of 30 feet, and the power being about 35 and 25 horse-power, respectively; and at Mount Holly Springs the same stream runs the two paper-mills of the Mount Holly Paper Company, each with a fall of 20 feet, and 110 horse-power during eight months, besides a third, with a fall of 13 feet, and 70 horse-power during eight months. Steam is used in all during the dry weather.

Conewago and Codorus creeks, from the west, are similar streams, but regarding their power I have no details. No sites of special importance were mentioned.

The first large tributary from the east below Harrisburg is Swatara creek, which rises in Schuylkill county and flows in a general southwesterly direction through Lebanon and Dauphin counties, draining an area of 536 square miles, and emptying into the Susquehanna at Middletown. The lower part of its course lies through a hilly and rolling farming country, the bed being generally gravel and sand, though sometimes rock, and the banks low and sometimes overflowed. Toward the head-waters, which approach those of the Schuylkill, the country is more broken, the banks higher, and the bed oftener rock. The fall of the stream is gradual, there being no natural falls or rapids of importance, except on the upper parts, and the slope does not exceed about 3 feet per mile for the first 25 or 30 miles. Regarding the flow I have no data. The character of the greater part of the drainage basin is not such as to cause the rapid discharge of storm-waters, the soil is cultivated, and the rainfall is quite favorably distributed, being largest in summer and autumn. The freshets are said to be not very violent, and the rises not very sudden. The stream is followed for about 25 miles by the Union canal, which connects Middletown with Reading, and for 10 or 12 miles farther by a branch of the canal extending to what seems from the map to be an artificial reservoir used as a feeder; but no details regarding it could be obtained. With this exception there are no lakes or artificial reservoirs in the basin, excepting mill-ponds. The power utilized on the stream will be found in the table on page 88, to which I can add little in the way of explanation. The grist-mills use only small amounts of power, running generally three pairs of stones. The first dam on the stream is one used as a feeder for the Pennsylvania canal, and is situated just above the mouth. It is a crib-work dam, 548 feet long and 7 feet high, backing the water less than a mile. A grist-mill is supplied from it, using a fall of 8 feet and running two pairs of stones; but as the water is diverted from the stream by a dam a short distance above, and carried by to supply a mill below, full capacity can be obtained during only about eight months. No sites of importance not utilized were spoken of, and it is probable that they do not exist. It was said, however, that the traffic on the Union canal is so small that it will soon be abandoned as a navigation canal, and that by using it as a race considerable water-power could be utilized; but at present no power is so used.

The next stream of importance from the east is Conestoga creek. Taking its rise in the southernmost corner of Berks county, it flows first west and then southwest, through Lancaster county, and within a mile or two of the town of the same name, emptying into the Susquehanna 10 or 12 miles below Columbia. It drains a rolling farming country, its bed is gravel and sand, its fall moderate, and its flow quite variable. It has no lakes or falls, and is utilized quite extensively by small grist-mills with from two to five pairs of stones, those near the mouth of the stream generally running all the year. The distribution of the rainfall is quite favorable for constancy of flow, and the stream is said to be fed largely from springs. No unimproved sites for power were discovered. Of those utilized we may mention the Slackwater paper-mills, some 5 miles from the mouth of the stream, using a fall of 12 feet and about 160 horse-power; the water-works at Lancaster, used for pumping water for the supply of the city, with a fall of 6 feet; and Levan's flour-mill, with a fall of 6 or 7 feet, and running seven pairs of stones night and day, but during only six or eight months. Many of the mill-ponds are large enough to allow of considerable storage during the night.

The remaining tributaries of the river below Columbia are small streams, and may be dismissed with a few words. From the west there are the following: Creitze creek, emptying at Wrightsville, opposite Columbia, a small stream, running a number of grist-mills with from three to five pairs of stones, some with extra steam-power, and none able to run in very dry weather; then a number of small streams running a few grist-mills, saw-mills, furnaces, founderies, etc.; Muddy creek, emptying about 3 miles above Peachbottom, with grist- and saw-mills, a forge, woolen-mill, and spoke factory on the stream and its branches; Broad creek, a smaller but similar stream; Deer creek, emptying at the head of tide-water, and running a number of grist-, saw-, and flint-mills, the former averaging three pairs of stones. These streams are all similar in general character, having a gradual fall, often quite large, beds of gravel and sand, banks generally low, no lakes or artificial reservoirs, no natural falls, and a quite variable flow. There are said to be numerous sites not used—for instance, six on Deer creek, within 12 miles of its mouth, the largest with an available fall of 12 feet. On some small secondary tributaries there are precipitous falls, some utilized.

From the west there are the following streams below the Conestoga: Pequea, Muddy, Fishing, Peter's, and Conewingo creeks, all with small mills; and Octorara creek, the most important, emptying at Rowlandville,

Maryland, about 3 miles above Port Deposit. At its mouth is the power of the McCullough Iron Company, with a dam about 170 feet long and 12 feet high. That the stream is subject to considerable freshets is shown by the fact that the original log dam at this place, built in 1828, was swept away in 1857, and that the stone dam by which it was replaced was also swept away in 1881. The present dam is of crib-work filled with stone and concrete. A race 100 yards long gives a fall of 14 feet, used for the rolling-mill, the power being stated at 120 horse-power during seven months, and one-half to two-thirds of that amount during the rest of the time. The pond is large enough to store the water in dry seasons during the four hours when power is not used. About a mile above this power is an unimproved site with a fall stated at 25 feet; and still farther up are a number of small mills, generally grist-mills, though there is one paper-mill near Rising Sun, Maryland, with a fall of 18 feet. The streams from the east have the same general character as those from the west, but seem to have more fall and higher banks. The Octorara is said to be an especially good stream for power, on account of its rapid fall and its favorable locations.

The principal fact that strikes one in considering the power of the Susquehanna is the comparative absence of large falls. And as regards the tributaries, the most prominent point is their gradual fall and the absence of cataracts like those on so many of the northern and southern rivers. On this account it has been impossible to give much of an idea of the available power which they offer or the sites which are capable of being developed with advantage.

The first of the following tables gives the drainage areas of the Susquehanna and tributaries, and the second the power utilized, tabulated from the returns of the enumerators:

Table of drainage areas of the Susquehanna river and tributaries.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
North branch of Susquehanna river	Atlantic ocean	Above mouth of Oak creek	97
Do	do	Below mouth of Oak creek	212
Do	do	Below mouth of Charlotte river	713
Do	do	Below mouth of Unadilla river	1,638
Do	do	Nineveh	1,789
Do	do	Susquehanna	2,024
Do	do	Binghamton	2,279
Do	do	Above mouth of Chemung river	4,945
Do	do	Below mouth of Chemung river	7,463
Do	do	Nanticoke	9,850
Do	do	Berwick	10,059
Do	do	Mouth	10,959
Do	do	Below mouth of West branch	17,425
Do	do	Clark's Ferry	18,829
Do	do	Below mouth of Juniata river	22,052
Do	do	Falmouth	23,859
Do	do	Columbia	24,835
Do	do	Mouth	26,233
Oak creek	North branch of Susquehanna river	do	115
Cherry Valley creek	do	do	121
Schenevas creek	do	do	127
Charlotte river	do	do	178
Otego creek	do	do	106
Oaliout creek	do	do	115
Unadilla river	do	do	561
Butternut creek	Unadilla river	do	123
Wharton creek	do	do	92
Bennett's creek	North branch of Susquehanna river	do	47
Chenango river	do	Above Canasawacta creek	297
Do	do	Above Tioughnioga creek	685
Do	do	Mouth	1,540
Canasawacta creek	Chenango river	do	63
Genegantslet creek	do	do	102
Tioughnioga river	do	Above mouth of Otselic river	428
Do	do	Mouth	735
West branch Tioughnioga river	Tioughnioga river	do	103
East branch Tioughnioga river	do	do	164
Otselic river	do	do	259
Starucca creek	North branch of Susquehanna river	do	75
Owego creek	do	do	391
Cayuta (Shepard's) creek	do	do	148
Chemung river	do	Junction of Canisteo and Conhocton rivers	1,941
Do	do	Elmira	2,107
Do	do	Mouth	2,518
Conhocton river	Chemung river	do	607
Tioga river	do	do	1,334
Do	do	Above mouth of Cowanesque creek	433

Table of drainage areas of the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Tioga river	Chemung river	Above mouth of Canisteo river	776
Canisteo river	..do	Mouth	545
Tuscarora creek	Canisteo river	...do	120
Cowanesque creek	Tioga river	...do	288
Sugar creek	North branch of Susquehanna river	...do	177
Towanda creek	...do	..do	220
Wysox creek	...do	...do	90
Wyalusing creek	..do	...do	204
Tunkhannock creek	...do	...do	409
Lackawanna creek	...do	...do	323
Little Wapwallopen creek	...do	...do	38
Big Wapwallopen creek	...do	..do	68
Nescopec creek	...do	...do	145
Catawissa creek	...do	...do	131
Fishing creek	...do	...do	353
West branch of Susquehanna river	Susquehanna river	Above mouth of Clearfield creek	476
Do	...do	Above mouth of Sinnemahoning creek	1,437
Do	...do	Queen's run	3,032
Do	...do	Lock Haven	3,041
Do	...do	Williamsport	5,300±
Do	...do	Muncy dam	6,010
Do	...do	Louisburg	6,308
Do	...do	Mouth	6,466
Clearfield creek	West branch of Susquehanna river	..do	342
Moshannon creek	...do	...do	233
Mosquito creek	...do	...do	54
Sinnemahoning creek	...do	Benezette	163
Do	...do	Driftwood	354
Do	...do	Mouth	962
Trout run	Sinnemahoning creek	...do	48
Driftwood branch	...do	...do	314
First fork	...do	...do	240
Kettle creek	West branch of Susquehanna river	...do	215
Bald Eagle creek	...do	...do	726
Beach creek	Bald Eagle creek	...do	157
Fishing creek	..do	...do	169
Spring creek	...do	...do	148
Pine creek	West branch of Susquehanna river	...do	930
Big Larry's creek	...do	...do	85
Lycoming creek	...do	...do	261
Loyalsock creek	...do	..do	494
Muncy creek	...do	...do	185
White Deer creek	...do	...do	40
Chillisquaque creek	..do	...do	119
Shamokin creek	North branch of Susquehanna river	...do	165
Mahanoy creek	...do	...do	133
Mahontongo creek	..do	...do	166
Wiconisco creek	...do	...do	83
Clark's creek	...do	..do	47
Penn's creek	..do	...do	361
Middle creek	...do	...do	147
Juniata river	Susquehanna river	Below junction of two branches	1,842
Do	...do	Newton Hamilton	2,270
Do	...do	Lewistown dam	2,550
Do	...do	Millerstown	2,990
Do	..do	Mouth	3,223
Raystown branch of	Juniata river	Hopewell	588
Do	...do	Mouth	909
Frankstown branch of	...do	Hollidaysburg	129
Do	...do	Crooked dam	249
Do	...do	Three-Mile dam	273
Do	...do	Williamsburg	279
Do	...do	Mud dam	333
Do	...do	Smoker's dam	333
Do	...do	Donnelly's dam	342
Do	...do	Willow dam	347
Do	...do	Water Street dam	356
Do	...do	Alexandria	360
Do	...do	Mouth of Little Juniata	374
Do	...do	Piper's dam	750

Table of drainage areas of the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Frankstown branch of	Juniata river	Huntingdon dam	759
Do	....do	Mouth	933
Standing Stone creek	Frankstown branch	....do	129
Shaver's creek	....do	....do	45
Little Juniata river	....do	Tyrone (including Bald Eagle creek)	154
Do	....do	Barree	325
Do	....do	Mouth	327
Spruce creek	Little Juniata river	....do	94
Bald Eagle creek	....do	....do	54
Great Aughwick creek	Juniata river	....do	316
Kishacoquillas creek	... do	... do	174
Jack's creek	... do	... do	55
Tuscarora creek	....do	....do	252
Swatara creek	Susquehanna river	....do	536
Conewago creek	....do	... do	58
Sherman's creek	... do	... do	232
Conedogwinit creek	... do	....do	450
Yellow Breeches creek	... do	....do	247
Pequea creek	... do	... do	148
Conestoga creek	....do	Lancaster	332
Do	....do	Mouth	474
Conewingo creek	....do	....do	31
Octorara creek	... do	....do	178
Deer creek	....do	....do	128

Table of utilized power on the Susquehanna river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
North branch of Susquehanna river	Atlantic ocean	New York	Otsego	Agricultural implements	1	5	10
Do	....do	....do	....do	Blacksmithing	1	5	10
Do	....do	....do	....do	Cotton-laps	1	8	15
Do	....do	....do	....do	Flouring and grist	4	32	170
Do	....do	... do	....do	Saw	14	82+	371
Do	....do	....do	....do	Planing	1	6	10
Do	....do	....do	....do	Machinery	1	7	7
Do	....do	....do	....do	Paper	1	6.5	15
Do	... do	....do	Delaware	Flouring and grist	1	......	80
Do	....do	....do	Chenango	.. do	3	22	170
Do	....do	....do	.. do	Saw	1	4	20
Do	....do	.. do	Broome	Woolen	1	7	6
Do	....do	....do	....do	Flouring and grist	5	20	113
Do	....do	....do	....do	Carriages, etc	2	13.5	70
Do	....do	....do	....do	Furniture	1	5.5	25
Do	....do	....do	....do		1	......	15
Do	....do	....do	....do	Blacksmithing	1	4	10
Do	....do	....do	....do	Leather	1	7.5	30
Do	....do	....do	....do	Saw (*a*)	(?)	(?)	(?)
Do	.. do	....do	....do	Wheelwrighting	1	......	12
Do	....do	....do	....do	Machinery	1	5	2
Do	....do	....do	....do	Furniture	1	......	10
Do	....do	Pennsylvania	Susquehanna	Sash, doors, and blinds	1	4.5	25
Do	....do	....do	....do	Saw	(?)	(?)	(?)
Do	....do	....do	....do	Flouring and grist	2	8	110
Do	....do	New York	Tioga	Saw	2	......	23
Do	....do	Pennsylvania	Bradford	....do	2	13	(?) 20
Do	....do	....do	....do	Flouring and grist	3	14	86
Do	....do	....do	Luzerne	... do (*b*)	1	10	......
Do	....do	....do	Columbia	Keg (*b*)	1	10	20
Do	....do	....do	.. do	Water-works (*b*)	1	7	......
Do	.. do	....do	Snyder	Saw (*b*)	1	8	40

a The power on the main stream used for saw-mills can not be distinguished from that on the tributaries. The total is given under the head of the tributaries.
b From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
North branch of Susquehanna river	Atlantic ocean	Pennsylvania	Perry	Saw (*a*)	1	7	23
Do	do	do	Dauphin	do (*a*)	1	7	....
Do	do	do	do	Flouring and grist (*a*)	1	15	60
Do	do	do	do	Canal shops (*a*)	1	11	....
Do	do	do	Lancaster	Saw (*b*)	1	6.5	70
Do	do	do	do	Flouring and grist (*b*)	1	....	(?)28
Tributaries of	Susquehanna river	New York	Otsego	Woolen	2	11	28
Do	do	do	do	Cotton	6	119	436
Do	do	do	do	Agricultural implements	3	26	46
Do	do	do	do	Butter and cheese	1	6	10
Do	do	do	do	Blacksmithing	1	6	12
Do	do	do	do	Box	2	32	25
Do	do	do	do	Keg	2	19	27
Do	do	do	do	Furniture	2	12	40
Do	do	do	do	Flouring and grist	35	481	1,103
Do	do	do	do	Saw	72	980	1,758
Do	do	do	do	Leather	7	83	167
Do	do	do	do	Last	1	16	20
Do	do	do	do	Machinery	3	30	58
Do	do	do	do	Paper	1	10	55
Do	do	do	do	Sash, door, and blind	1	13	20
Do	do	do	do	Wheelwrighting	5	57	104
Do	do	do	do	Wooden ware	1	8	18
Do	do	do	Schoharie	Foundery	1	16	4
Do	do	do	do	Planing	1	18	8
Do	do	do	do	Wheelwrighting	1	18	8
Do	do	do	do	Flouring and grist	1	20	30
Do	do	do	do	Saw	5	68	92
Do	do	do	Delaware	Flouring and grist	9	110	300
Do	do	do	do	Woolen	1	9	15
Do	do	do	do	Saw	15	196	409
Do	do	do	do	Leather	1	3	24
Do	do	do	do	Machinery	1	7	4
Do	do	do	do	Wheelwrighting	1	12	5
Do	do	do	Herkimer	Box	2	17	90
Do	do	do	do	Flouring and grist	2	33	65
Do	do	do	do	Saw	1	22	30
Chenango river	do	do	Madison	Carriage	2	20	5
Do	do	do	do	Flouring and grist	2	53	50
Do	do	do	do	Saw	2	19	73
Do	do	do	do	Leather	1	8	10
Do	do	do	do	Wheelwrighting	1	9	2
Do	do	do	Chenango	Flouring and grist	5	24	240
Do	do	do	do	Fertilizers	1	4	10
Do	do	do	do	Planing	1	4.5	15
Do	do	do	Broome	Flouring and grist	4	21.5	265
Do	do	do	do	Broom and brush	1	4.5	12
Do	do	do	do	Saw	1	7	25
Do	do	do	do	Paper	1	4.5	80
Do	do	do	do	Foundery	1	4	18
Tributaries of	Chenango river	do	Madison	Keg	1	8	10
Do	do	do	do	Butter and cheese	1	10	4
Do	do	do	do	Flouring and grist	11	153	376
Do	do	do	do	Furniture	2	17	18
Do	do	do	do	Saw	19	260	550
Do	do	do	do	Planing	1	13	18
Do	do	do	do	Leather	1	22	6
Do	do	do	do	Pumps	1	24	12
Do	do	do	do	Wheelwrighting	2	16	12
Do	do	do	do	Woolen	3	50	148
Do	do	do	do	Silk	1	23.5	76
Do	do	do	Onondaga	Flouring and grist	2	42	41
Do	do	do	do	Flax-dressing	1	10	7
Do	do	do	do	Saw	1	10	24
Do	do	do	Cortland	Blacksmithing	2	7.5	5
Do	do	do	do	Woolen	1	6	4

a From Pennsylvania canal. *b* From Columbia dam.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Chenango river	New York	Cortland	Carriage	1	10	8
Do	do	do	do	Keg	2	12	25
Do	do	do	do	Cutlery	1	6	12
Do	do	do	do	Flouring and grist	22	317	685
Do	do	do	do	Furniture	3	32	25
Do	do	do	do	Flax-dressing	1	9	9
Do	do	do	do	Saw	28	303	785
Do	do	do	do	Leather	3	36	34
Do	do	do	do	Machinery	1	5	8
Do	do	do	do	Vegetable oil	1	6	23
Do	do	do	do	Wooden ware	1	6.5	12
Do	do	do	Chenango	Agricultural implements	2	16	43
Do	do	do	do	Woolen	3	....	35
Do	do	do	do	Box	1	6	25
Do	do	do	do	Blacksmithing	2	18	18
Do	do	do	do	Cutlery	1	9	30
Do	do	do	do	Carpenter-shop	1	9	10
Do	do	do	do	Flouring and grist	17	108	295
Do	do	do	do	Dyestuffs and extracts	1	9	20
Do	do	do	do	Furniture	1	8	15
Do	do	do	do	Saw	10	97	219
Do	do	do	do	Lumber	36	515	1,007
Do	do	do	do	Planing	1	8	15
Do	do	do	do	Leather	2	26	20
Do	do	do	do	Machinery	1	4	4
Do	do	do	do	Wheelwrighting	1	11	38
Do	do	do	Broome	Flouring and grist	6	75	160
Do	do	do	do		1	15	10
Do	do	do	do	Saw	8	77	380
Do	do	do	do	Furniture	1	7	5
Other tributaries of	North branch of Susquehanna river	do	Madison	Box	1	11	30
Do	do	do	do	Flouring and grist	4	52	130
Do	do	do	do	Saw	4	49	72
Do	do	do	do	Planing	1	8	18
Do	do	do	do	Leather	1	22	56
Do	do	do	Chenango	Keg	1	7	10
Do	do	do	do	Woolen	1	4	20
Do	do	do	do	Flouring and grist	8	161	224
Do	do	do	do	Drugs and chemicals	1	28	32
Do	do	do	do	Furniture	2	28	20
Do	do	do	do	Foundery	1	14	5
Do	do	do	do	Saw	14	163	357
Do	do	do	do	Sash, doors, and blinds	1	5	25
Do	do	do	Broome	Flouring and grist	7	63	237
Do	do	do	do	Agricultural implements	1	6	8
Do	do	do	do	Clothing	1	....	1
Do	do	do	do	Beehives	1	....	4
Do	do	do	do	Leather	2	16	18
Do	do	do	do	Saw	23	283	607
Do	do	do	do	Furniture	1	4.5	20
Do	do	do	do	Wheelwrighting	1	6	15
Do	do	Pennsylvania	Wayne	Saw	6	96	186
Do	do	do	do	Flouring and grist	1	11	30
Do	do	New York	Tioga	Agricultural implements	1	6.5	18
Do	do	do	do	Woolen	1	8	20
Do	do	do	do	Blacksmithing	2	11.5	18
Do	do	do	do	Cutlery	1	5	6
Do	do	do	do	Keg	2	16.5	23
Do	do	do	do	Dyestuffs	1	8	20
Do	do	do	do	Fertilizers	1	6	10
Do	do	do	do	Saw	26	215	871
Do	do	do	do	Paper	1	10	80
Do	do	do	do	Leather	2	17	45
Do	do	do	do	Wheelwrighting	2	15	28
Do	do	do	do	Flouring and grist	13	114	516
Do	do	do	Chemung	do	2	15	90

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	North branch of Susquehanna river.	New York	Tompkins	Saw	2	26	(?) 65
Do	...do	...do	Schuyler	...do	3	24	77
Do	...do	...do	...do	Flouring and grist	2	20	65
Chemung river	...do	Pennsylvania	Bradford	Planing	1	5	13
Do	...do	...do	...do	Flouring and grist	1	5	18
Do	...do	New York	Chemung	...do	2	10	85
Tributaries of	Chemung river	Pennsylvania	Bradford	Saw	2	40	(?) 80
Do	...do	...do	...do	Flouring and grist	1	17	30
Do	...do	New York	Chemung	...do	9	92	305
Do	...do	...do	...do	Saw	12	124	304
Do	...do	...do	...do	Woolen	1	16	8
Do	...do	...do	Steuben	Saw	3	38	97
Conhocton river	Chemung river	...do	...do	Fertilizers	1	9	40
Do	...do	...do	...do	Flouring and grist	10	83	485
Do	...do	...do	...do	Saw	3	41	130
Do	...do	...do	...do	Leather	1	6	10
Tributaries of	Conhocton river	...do	...do	Flouring and grist	5	75+	128
Do	...do	...do	...do	Saw	3	....	50
Do	...do	...do	Schuyler	Flouring and grist	2	52	87
Do	...do	...do	...do	Saw	1	22	25
Canisteo river	Chemung river	...do	Steuben	Flouring and grist	7	62	327
Do	...do	...do	...do	Saw	5	41	149
Do	...do	...do	...do	Sash, door, and blind	1	5	60
Do	...do	...do	Allegany	Drugs and chemicals	1	13	1
Tributaries of	Canisteo river	...do	Steuben	Agricultural implements	1	12	20
Do	do	...do	...do	Flouring and grist	9	154	239
Do	...do	...do	...do	Saw	11	125+	289
Do	...do	...do	...do	Leather	1	15	21
Do	...do	...do	...do	Paints	1	....	5
Do	...do	...do	...do	Woolen	1	11	15
Do	...do	...do	Allegany	Saw	1	18	15
Do	...do	...do	...do	Flouring and grist	8	82	115
Tioga river	Chemung river	...do	Steuben	...do	2	10.5	55
Do	...do	...do	...do	Saw	4	25	(?) 475
Do	...do	Pennsylvania	Tioga	Agricultural implements	1	10	50
Do	...do	...do	...do	Saw	8	73	278
Do	...do	...do	...do	Flouring and grist	8	28	92
Tributaries of	Tioga river	New York	Steuben	...do	1	20	30
Do	...do	Pennsylvania	Tioga	Planing	1	7	20
Do	...do	...do	...do	Wheelwrighting	1	16	20
Do	...do	...do	...do	Saw	8	68	275
Do	...do	...do	...do	Leather	2	26	30
Do	...do	...do	...do	Flouring and grist	12	190	378
Do	...do	...do	...do	Woolen	1	5	16
Do	do	...do	Potter	Saw	2	41	51
Sugar creek	North branch of Susquehanna river.	...do	Bradford	Carriage	1	30	60
Do	...do	...do	...do	Flouring and grist	5	56	181
Do	...do	...do	...do	Saw	3	45	72
Do	...do	...do	...do	Woolen	1	7	30
Towanda creek	...do	...do	...do	Saw	1	6	30
Do	...do	...do	...do	Flouring and grist	7	91	223
Tunkhannock creek	...do	...do	Wyoming	Flouring and grist	3	25	134
Do	...do	...do	Susquehanna	Agricultural implements	1	8	4
Do	...do	...do	...do	Furniture	1	12	15
Do	...do	...do	...do	Saw	6	75	122
Do	...do	...do	...do	Leather	1	8	15
Do	...do	...do	...do	Flouring and grist	5	60	156
Lackawanna river	...do	...do	Lackawanna	Agricultural implements	1	10	55
Do	...do	...do	...do	Cutlery	1	10	55
Do	...do	...do	...do	Carpenter-shop	1	10	30
Do	...do	...do	...do	Gunpowder	1	15	20
Do	...do	...do	...do	Leather	1	12	35
Do	...do	...do	...do	Saw	2	22	26
Do	...do	...do	...do	Flouring and grist	4	56	71
Do	...do	...do	Susquehanna	Blacksmithing	1	18	8
Do	...do	...do	...do	Furniture	1	14	18

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse power used, net.
						Feet.	
Lackawanna river	North branch of Susquehanna river	Pennsylvania	Susquehanna	Saw	6	86	115
Do	do	do	do	Flouring and grist	1	20	40
Other tributaries of	do	do	Bradford	Woolen	8	....	22
Do	do	do	do	Blacksmithing	1	12	5
Do	do	do	do	Foundery	1	11	13
Do	do	do	do	Flouring and grist	24	389	564
Do	do	do	do	Saw	25	370	530
Do	do	do	do	Leather	1	20	20
Do	do	do	do	Sash, door, and blind	1	8	10
Do	do	do	do	Toys and games	1	9	60
Do	do	do	Susquehanna	Woolen	2	34	28
Do	do	do	do	Drugs and chemicals	1	....	10
Do	do	do	do	Furniture	5	55	87
Do	do	do	do	Chair	2	26	45
Do	do	do	do	Planing	1	18	18
Do	do	do	do	Machinery	1	16	15
Do	do	do	do	Wheelwrighting	5	59	31
Do	do	do	do	Wooden ware	1	14	20
Do	do	do	do	Saw	55	761+	1,556
Do	do	do	do	Leather	9	140+	292
Do	do	do	do	Flouring and grist	26	374+	646
Do	do	do	Wyoming	Agricultural implements	2	26	24
Do	do	do	do	Blacksmithing	1	8	12
Do	do	do	do	Keg	1	27	30
Do	do	do	do	Planing	3	52	54
Do	do	do	do	Toys and games	1	21	30
Do	do	do	do	Flouring and grist	20	374	657
Do	do	do	do	Leather	2	26	32
Do	do	do	do	Saw	26	428+	599
Do	do	do	Lackawanna	Woolen	1	9	8
Do	do	do	do	Agricultural implements	1	15	10
Do	do	do	do	Baskets, etc	1	13	20
Do	do	do	do	Furniture	2	19	57
Do	do	do	do	Foundery	1	31	7
Do	do	do	do	Gunpowder	1	36	68
Do	do	do	do	Leather	1	10	10
Do	do	do	do	Saw	6	78	187
Do	do	do	do	Flouring and grist	8	107	216
Do	do	do	Luzerne	Woolen	3	....	40
Do	do	do	do	Agricultural implements	2	12	20
Do	do	do	do	Flouring and grist	41	658	900
Do	do	do	do	Leather	2	....	35
Do	do	do	do	Saw	37	473+	722
Do	do	do	do	Paper	1	11	39
Do	do	do	do	Wheelwrighting	1	5	6
Do	do	do	Columbia	Agricultural implements	1	9	10
Do	do	do	do	Blacksmithing	1	10	10
Do	do	do	do	Planing	1	8	20
Do	do	do	do	Woolen	2	....	32
Do	do	do	do	Flouring and grist	33	459	843
Do	do	do	do	Leather	1	17	16
Do	do	do	do	Saw	27	385	601
Do	do	do	do	Blomary and forge	1	8	120
Do	do	do	do	Blast-furnace	1	22	170
Do	do	do	do	Paper	2	20	110
Do	do	do	do	Wheelwrighting	1	12	24
Do	do	do	Montour	Printing and publishing	3	....	3
Do	do	do	do	Flouring and grist	5	85	108
Do	do	do	Sullivan	Flouring and grist	1	15	15
Do	do	do	Northumberland	do	1	24	25
Do	do	do	do	Saw	1	12	25
West branch of Susquehanna river	Susquehanna river	do	do	Saw (*a*)	1	11	20
Do	do	do	Lycoming	Flouring and grist	1	9	100
Do	do	do	do	Saw	1	9	....
Do	do	do	Clearfield	Flouring and grist	6	36	205

a From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
West branch of Susquehanna river	Susquehanna river	Pennsylvania	Clearfield	Saw	4	31	134
Do	do	do	Cambria	do	1	10	30
Do	do	do	do	Flouring and grist	1	19	30
Muncy creek	West branch of Susquehanna river	do	Sullivan	Saw	5	59	131
Do	do	do	Lycoming	Carriages and sleds	1	11	12
Do	do	do	do	Carriage materials	1	6	12
Do	do	do	do	Flouring and grist	9	108	368
Do	do	do	do	Leather	1	5	27
Do	do	do	do	Saw	16	217+	334
Do	do	do	do	Woolen	1	14	20
Loyalsock creek	do	do	Sullivan	Saw	4	46	90
Do	do	do	do	Woolen	1	8	10
Do	do	do	do	Flouring and grist	3	34	120
Do	do	do	Lycoming	do	2	24	95
Do	do	do	do	Saw	10	108	433
Lycoming creek	do	do	Tioga	Flouring and grist	1	20	20
Do	do	do	Lycoming	do	4	35	235
Do	do	do	do	Saw	5	44	175
Do	do	do	do	Nail	1	10	120
Pine creek	do	do	Potter	Flouring and grist	1	12	30
Do	do	do	do	Saw	2	26	30
Do	do	do	Tioga	do	1	7	30
Do	do	do	Lycoming	Flouring and grist	2	18	65
Do	do	do	do	Saw	2	15	110
Do	do	do	Clinton	Flouring and grist	1	7	30
Do	do	do	do	Saw	1	6	24
Bald Eagle creek	do	do	Centre	Furniture	1	7	8
Do	do	do	do	Planing	1	8	15
Do	do	do	do	Stone and earthen ware	1	3.5	5
Do	do	do	do	Saw	1	6	8
Do	do	do	do	Flouring and grist	8	105	102
Do	do	do	do	Blast-furnace	1	12	....
Do	do	do	do	Forges	2	19	....
Do	do	do	do	Rolling-mills	2	13	....
Do	do	do	Clinton	Paper (*a*)	1	10	....
Do	do	do	do	Flour and grist	1	10	....
Fishing creek	Bald Eagle creek	do	do	Edge-tools	2	17	189
Do	do	do	do	Wheelwrighting	1	5	20
Do	do	do	do	Flouring and grist	5	45	125
Do	do	do	do	Saw	1	8	16
Do	do	do	do	Woolen	1	4	12
Do	do	do	do	Blast-furnace (*b*)	1	16	....
Do	do	do	do	Blomary and forge (*a*)	1	15	....
Spring creek	do	do	Centre	Woolen	3	30	50
Do	do	do	do	Blast-furnace	1	12	45
Do	do	do	do	Blomary and forge	1	12	40
Do	do	do	do	Agricultural implements	1	9	8
Do	do	do	do	Rolling-mill	1	12	60
Do	do	do	do	Machinery	1	9	20
Do	do	do	do	Telegraph and telephone apparatus	1	14	80
Do	do	do	do	Paper	1	12	30
Do	do	do	do	Saw	1	9	12
Do	do	do	do	Flouring and grist	7	87	232
Other tributaries of	West branch of Susquehanna river	do	Montour	Furniture	2	6	8
Do	do	do	do	Flouring and grist	4	37	62
Do	do	do	Northumberland	do	7	76	155
Do	do	do	Union	do	14	188	294
Do	do	do	do	Saw	3	47	52
Do	do	do	do	Leather	1	8	8
Do	do	do	Sullivan	Drugs and chemicals	1	30	8
Do	do	do	do	Saw	16	256	422
Do	do	do	do	Flouring and grist	4	84	140
Do	do	do	Tioga	Wheelwrighting	1	6	4
Do	do	do	do	Saw	7	78	140

a Not running in 1880. *b* Idle.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	West branch of Susquehanna river	Pennsylvania	Tioga	Flouring and grist	2	28	68
Do	...do	...do	Lycoming	Agricultural implements	1	9	7
Do	...do	...do	...do	Carriage materials	1	11	12
Do	...do	...do	...do	Marble- and stone-working.	1	....	3
Do	...do	...do	...do	Flouring and grist	16	253	465
Do	...do	...do	...do	Woolen	3	54	95
Do	...do	...do	...do	Leather	2	16	28
Do	...do	...do	...do	Saw	74	1,226	1,601
Do	...do	...do	...do	Paint	1	25	25
Do	...do	...do	...do	Shirt	1	....	5
Do	...do	...do	...do	Wood-turning	1	14	35
Sinnemahoning creek	...do	...do	Clinton	Saw	1	3	25
Do	...do	...do	Cameron	...do	1	9	20
Do	...do	...do	...do	Flouring and grist	1	9	40
Do	...do	...do	Elk	Saw	1	16	10
Do	...do	...do	...do	Flouring and grist	1	6	16
Other tributaries of	...do	...do	Centre	Rolling-mill	1	13	90
Do	...do	...do	...do	Foundery	1	18	2
Do	...do	...do	...do	Blast-furnaces	2	....	35
Do	...do	...do	...do	Leather	1	12	8
Do	...do	...do	...do	Saw	6	84	139
Do	...do	...do	...do	Flouring and grist	12	156+	240
Do	...do	...do	...do	Woolen	1	14	25
Do	...do	...do	Clinton	Agricultural implements	1	10	6
Do	...do	...do	...do	Foundery	1	18	8
Do	...do	...do	...do	Flouring and grist	10	136	295
Do	...do	...do	...do	Saw	16	274	388
Do	...do	...do	...do	Brick and tile	2	26	33
Do	...do	...do	...do	Woolen	2	....	50
Do	...do	...do	Potter	Flouring and grist	1	9	6
Do	...do	...do	...do	Saw	2	13	25
Do	...do	...do	Cameron	Flouring and grist	2	20	43
Do	...do	...do	...do	Saw	3	23	80
Do	...do	...do	Elk	...do	4	67	88
Do	...do	...do	...do	Flouring and grist	3	46	44
Do	...do	...do	Clearfield	Agricultural implements	1	8	8
Do	...do	...do	...do	Furniture	1	7	4
Do	...do	...do	...do	Flouring and grist	18	239	438
Do	...do	...do	...do	Saw	31	388	814
Do	...do	...do	...do	Woolen	1	8	12
Do	...do	...do	Cambria	Saw	14	159	334
Do	...do	...do	...do	Flouring and grist	5	88	102
Do	...do	...do	Indiana	Saw	5	....	38
Do	Susquehanna river below junction of North and West branches.	...do	Northumberland	Flouring and grist	24	330+	453
Do	...do	...do	...do	Saw	4	27	68
Do	...do	...do	Union	Agricultural implements	1	23	23
Do	...do	...do	...do	Saw	3	36	37
Do	...do	...do	...do	Flouring and grist	2	17	46
Do	...do	...do	Snyder	Leather	2	....	7
Do	...do	...do	...do	Saw	12	....	200
Do	...do	...do	...do	Flouring and grist	27	223+	554
Do	...do	...do	Centre	Agricultural implements	1	8	4
Do	...do	...do	...do	Foundery	1	12	3
Do	...do	...do	...do	Planing	1	12	3
Do	...do	...do	...do	Wheelwrighting	1	5	4
Do	...do	...do	...do	Saw	23	310+	374
Do	...do	...do	...do	Flouring and grist	16	215+	516
Juniata river	Susquehanna river	...do	Perry	...do (*a*)	1	15	....
Do	...do	...do	Huntingdon	Saw (*a*)	1	10	....
Tuscarora creek	Juniata river	...do	...do	Flouring and grist	1	14	18
Do	...do	...do	Juniata	...do	2	28	17
Do	...do	...do	Franklin	...do	2	24	18
Do	...do	...do	...do	Leather	1	14	10
Kishacoquillas creek	...do	...do	Mifflin	Cutlery and edge-tools	1	24	262

a From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Kishacoquillas creek	Juniata river	Pennsylvania	Mifflin	Furniture	1	3	3
Do	do	do	do	Flouring and grist	6	76	196
Do	do	do	do	Saw	2	18	16
Do	do	do	do	Woolen	1	9	10
Do	do	do	do	Rolling-mill	1	13	100
Great Aughwick creek	do	do	Fulton	Flouring and grist	2	30	40
Do	do	do	Huntingdon	do	2	12	40
Raystown branch of	do	do	Bedford	Blast-furnace (*a*)	1	7	....
Do	do	do	do	Woolen	1	4	10
Do	do	do	do	Flouring and grist	6	(?) 112	150
Frankstown branch of	do	do	Blair	do	2	....	50
Do	do	do	do	Blomary and forge	1	14	23
Do	do	do	do	Blomary and forge (*b*)	1	12	....
Do	do	do	Huntingdon	Planing	1	8	*c* 32
Do	do	do	do	Flouring and grist	2	16	....
Do	do	do	do	Saw	2	16	....
Do	do	do	do	Plaster	1	8	....
Other tributaries of	do	do	Perry	Agricultural implements	1	5	16
Do	do	do	do	Leather	1	12	8
Do	do	do	do	Flouring and grist	12	172	183
Do	do	do	do	Saw	5	49	54
Do	do	do	do	Woolen	3	37	31
Do	do	do	Juniata	Agricultural implements	1	8	2
Do	do	do	do	Glue	1	5	10
Do	do	do	do	Founderies	2	26	50
Do	do	do	do	Leather	2	36	10
Do	do	do	do	Flouring and grist	24	404	438
Do	do	do	do	Saw	6	75+	45
Do	do	do	do	Woolen	1	12	12
Do	do	do	Mifflin	Agricultural implements	1	10	8
Do	do	do	do	Machinery	1	10	8
Do	do	do	do	Woolen	3	62	51
Do	do	do	do	Leather	1	4	2
Do	do	do	do	Flouring and grist	15	259	334
Do	do	do	do	Saw	8	111+	122
Do	do	do	Fulton	Flouring and grist	7	119	117
Do	do	do	do	Saw	3	30	69
Do	do	do	Huntingdon	Cutlery and edge-tools	1	9	25
Do	do	do	do	Blast-furnace	1	11	50
Do	do	do	do	Blomary and forge	1	11	40
Do	do	do	do	Planing	1	18	25
Do	do	do	do	Flouring and grist	46	646+	961
Do	do	do	do	Saw	19	225	224
Do	do	do	do	Leather	2	....	22
Do	do	do	do	Woolen	2	....	18
Do	do	do	Bedford	Founderies	2	19	[illegible]
Do	do	do	do	Woolen	4	....	32
Do	do	do	do	Leather	1	10	4
Do	do	do	do	Saw	15	181	226
Do	do	do	do	Flouring and grist	47	698	771
Do	do	do	Blair	Agricultural implements	1	4	10
Do	do	do	do	Woolen	1	3	9
Do	do	do	do	Flouring and grist	30	440	530
Do	do	do	do	Leather	1	2	4
Do	do	do	do	Saw	1	19	30
Do	do	do	do	Blast-furnace	1	20	20
Do	do	do	do	Blast-furnaces (*a*)	2	50	....
Do	do	do	do	Hardware	1	8	10
Do	do	do	do	Planing	1	29	12
Do	do	do	do	Paper	1	33	40
Conedogwinet creek	Susquehanna river	do	Franklin	Flouring and grist	5	44	79
Do	do	do	do	Saw	2	23	27
Do	do	do	Cumberland	Flouring and grist	9	62	229
Do	do	do	do	Saw	2	11	35
Do	do	do	do	Nail- and rolling mill	1	7	(?) 300

a Not in blast. *b* Not in operation. *c* From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total horse-power used, net.
						Feet.	
Yellow Breeches creek	Susquehanna river	Pennsylvania	Cumberland	Planing	1	10	25
Do	do	do	do	Flouring and grist	21	160	700
Do	do	do	do	Saw	1	4	66
Do	do	do	do	Sash, door, and blind	1	3	9
Do	do	do	do	Blomary and forge	1	8	24
Do	do	do	do	Woolen	1	7	20
Swatara creek	do	do	Schuylkill	Saw	5	39	81
Do	do	do	do	Flouring and grist	4	45	70
Do	do	do	Lebanon	do	5	20	90
Do	do	do	do	Saw	1	3	25
Do	do	do	do	Blomary and forge	1	8	35
Do	do	do	Dauphin	Flouring and grist	5	26+	127
Do	do	do	do	Saw	1	12	50
Conestoga creek	do	do	Berks	Flouring and grist	3	48	46
Do	do	do	Lancaster	do	27	204+	868
Do	do	do	do	Foundery	1	3	12
Do	do	do	do	Saw	1	4	10
Do	do	do	do	Paper	2	18	202
Do	do	do	do	Water-works	1	6	......
Octorara creek	do	do	Chester	Flouring and grist	5	82	65
Do	do	do	do	Plaster	1	6	50
Do	do	do	Lancaster	Flouring and grist	3	37	70
Do	do	do	do	Machinery	1	10	12
Do	do	do	do	Blomary and forge	1	14	40
Do	do	Maryland	Cecil	Rolling	1	......	......
Do	do	do	do	Paper	1	18	150
Do	do	do	do	Flouring and grist	1	12	72
Other tributaries of	do	Pennsylvania	Juniata	Leather	1	3	5
Do	do	do	do	Flouring and grist	2	20	42
Do	do	do	Perry	Agricultural implements	1	10	10
Do	do	do	do	Blomaries and forges	2	44	50
Do	do	do	do	Flouring and grist	21	312	357
Do	do	do	do	Woolen	1	10	5
Do	do	do	do	Saw	12	132+	167
Do	do	do	Franklin	Flouring and grist	1	10	12
Do	do	do	do	Leather	1	12	10
Do	do	do	Cumberland	Dyeing and cleaning	1	8	5
Do	do	do	do	Woolen	1	10	10
Do	do	do	do	Leather	1	22	15
Do	do	do	do	Flouring and grist	25	263	544
Do	do	do	do	Saw (*a*)	9	72	152
Do	do	do	do	Paper	4	68	270
Do	do	do	do	Blomaries and forges	3	44	130
Do	do	do	York	Agricultural implements	1	11	10
Do	do	do	do	Woolen	4	35+	59
Do	do	do	do	Twine, etc	1	21	25
Do	do	do	do	Dyewoods, etc	1	14	12
Do	do	do	do	Fertilizers	2	30	25
Do	do	do	do	Gunpowder	1	22	30
Do	do	do	do	Blast-furnace (*a*)	1	28	......
Do	do	do	do	Paper	2	16	135
Do	do	do	do	Saw	30	476	530
Do	do	do	do	Leather	6	90	60
Do	do	do	do	Brick and tile	1	11	3
Do	do	do	do	Flouring and grist	134	2,024	2,667
Do	do	do	Adams	Leather	1	7	4
Do	do	do	do	Woolen	2	......	22
Do	do	do	do	Saw	22	240	259
Do	do	do	do	Flouring and grist	33	438	633
Do	do	do	Schuylkill	Agricultural implements	1	6	16
Do	do	do	do	Saw (*a*)	3	12	35
Do	do	do	do	Woolen	1	8	16
Do	do	do	do	Leather	1	13	14
Do	do	do	do	Flouring and grist	14	167	208
Do	do	do	Lebanon	Agricultural implements	1	6	8

a Not in operation.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Susquehanna river	Pennsylvania	Lebanon	Blomary and forge	1	7	30
Do	do	do	do	Flouring and grist	24	264	654
Do	do	do	do	Saw	3	30	48
Do	do	do	Dauphin	Flouring and grist	53	671	995
Do	do	do	do	Cotton	1	14	10
Do	do	do	do	Dyeing and cleaning	1	......	[illegible]
Do	do	do	do	Blomary and forge	1	10	70
Do	do	do	do	Saw	18	112+	232
Do	do	do	do	Leather	3	35	32
Do	do	do	do	Woolen	1	15	10
Do	do	do	do	Tin, copper, and sheet-iron ware.	1	......	2
Do	do	do	Berks	Flouring and grist	9	121	107
Do	do	do	Lancaster	Agricultural implements	1	[illegible]	12
Do	do	do	do	Woolen	6	67+	96
Do	do	do	do	Blacksmithing	1	10	2
Do	do	do	do	Blomaries and forges	2	35	47
Do	do	do	do	Carpenter-shop	1	11	20
Do	do	do	do	Carriage materials	1	20	15
Do	do	do	do	Flouring and grist	168	2,214	3,666
Do	do	do	do	Fertilizers	1	7	8
Do	do	do	do	Furniture	1	3	10
Do	do	do	do	Foundery	1	10	8
Do	do	do	do	Leather	2	18	13
Do	do	do	do	Saw	21	281	364
Do	do	do	do	Machinery	1	10	8
Do	do	do	do	Wheelwrighting	2	19	16
Do	do	do	Chester	Flouring and grist	[illegible]	99	59
Do	do	do	do	Saw	2	30	26
Do	do	do	do	Paper	2	41	76
Do	do	Maryland	Cecil	Saw	2	24	17
Do	do	do	do	Flouring and grist	10	196	241
Do	do	do	Harford	do	21	346	410
Do	do	do	do	Saw	12	166+	173
Do	do	do	do	Fertilizers	1	15	45
Do	do	do	do	Agricultural implements	1	27	12
Do	do	do	do	Bark	1	24	15
Do	do	do	do	Kaolin	4	59	196
Do	do	do	do	Woolen	1	22	8

VII.—THE DELAWARE RIVER AND TRIBUTARIES.

THE DELAWARE RIVER.

The Delaware, like the Susquehanna, takes its rise beyond the mountains proper, on the high plateau of central New York, its sources lying in Greene, Schoharie, and Delaware counties. The West branch, commonly called the main stream, rises in a small lake almost on the line between Delaware and Schoharie counties, at an elevation above the sea of about 1,886 feet.(*a*) Pursuing a devious course in a southwesterly direction through Delaware county for a distance of about 70 miles, to the line of Broome county, where it is within 10 miles of the Susquehanna river, and passing the towns of Delhi and Deposit, it suddenly turns to the southeast, and 6 or 7 miles below becomes the boundary line between Pennsylvania and New York. About 7 miles farther down it receives from the left the East branch, or Pepacton, which rises in Delaware and Greene counties, about 50 miles to the northeast in a straight line, and pursues a course nearly parallel to the main branch. From the junction of the two the river proceeds in a southeasterly direction for a distance of about 90 miles, receiving from the right the Lackawaxen river, and from the left the Neversink creek. At its junction with the latter, at Carpenter's point, about a mile below the town of Port Jervis, New York, it turns to the southwest along the base of the Kittatinny

a McCullough's *Geographical Dictionary*, Vol. I, p. 739.

mountains, until it crosses the range about 40 miles below, through the breach called the "Delaware Water Gap". It then flows in a southerly direction for a distance of about 37 miles, receiving at Belvidere the Pequest creek from New Jersey, at Easton, Pennsylvania, and Phillipsburg, New Jersey, the Lehigh river from the right, and, a few miles below, the Musconetcong from New Jersey, where it passes the gap in the South mountains. Then flowing toward the southeast for a distance of about 48 miles by the cities of Lambertville, Trenton, and Bordentown, New Jersey, it changes its course at the latter place, and runs onward, past Philadelphia and Camden, through Delaware bay to the ocean. From Carpenter's point it forms the boundary between New Jersey on the left, and Pennsylvania and Delaware on the right. Following all its windings, the length of the stream from its source to Trenton is about 280 miles, and its average fall is about 6.7 feet per mile, or much larger than that of the Susquehanna. The total length of the stream, down to the "capes of the Delaware", or to the Atlantic ocean, is about 410 miles; and the area drained, down to and including the Schuylkill, which enters at Philadelphia, is about 10,100 square miles, of which area about 2,580 square miles are comprised in New York, 5,720 in Pennsylvania, and 1,800 in New Jersey. The table of drainage areas on pages 78 to 80 gives detailed information regarding the areas drained by the various tributaries, and the accompanying map will show their locations.

The general topographical features of the Delaware have been described in the following words by Professor Rogers:(a)

This noble river, the eastern boundary of Pennsylvania throughout its entire breadth, exhibits, along its immediate valley, a considerable variety of topographical features and scenery. From its head streams in New York, to where it emerges from the Pocono, or Catskill, mountain, it flows in a tortuous course through a deep narrow trough in that elevated table-land. The mean level of the plateau remaining nearly constant, and the valley growing progressively deeper, the river-hills, which are all that the traveler at the river-side usually beholds, grow higher and steeper as he descends. Meandering much more than the valley containing it, the river sweeps sometimes close by the base of the bounding hills, the lower parts of which are, in many cases, faced by high, naked cliffs, exposing the reddish-brown shales and sandstones of the district, in beautiful contrast with the mixed green hues of the foliage. The perspective of jutting and retreating hills, clothed for the most part with a combination of coniferous and deciduous forest to their summits, and washed at their base by long, bending reaches of the broad river, are very attractive, notwithstanding a prevailing sameness in general feature. After leaving the plateau in Pike and Wayne counties, the river emerges into a broad open valley, wholly different in aspect and structure from that which it has left. The waters which carved a way for it seem to have been impelled in their momentum southward with great energy against the strong, stony barrier of the Kittatinny, or Shawangunk, mountain, and to have scooped their deepest trench near the base of that high ridge. The river, therefore, turns abruptly at Carpenter's point from a southeast to a southwest course, and follows the foot of the mountain, sometimes hugging its base, sometimes sweeping a moderate distance from it into the plain, until it finds a passage through it by the great breach called the "Delaware Water Gap". The scenery along this stretch of the river is eminently beautiful. Low within the valley, the river is bordered by fertile cultivated flats, variously carved in one or more terraces, and behind these, particularly on the northwest, rise numerous rolling hills, some under the plow, some covered with timber, all deeply cut by ravines, in the steeper of which are many beautiful water-falls, while still beyond the hills we see ascending the long slopes or bold escarpments of the plateau of the Upper Delaware. All the way along our left the view is bounded by the forest-covered flank and straight crest of the Kittatinny mountain.

Turning at the water-gap, the Delaware, in issuing through the main ridge of the mountain, passes between steep, nearly perpendicular, mural cliffs of gray sandstone, rising on either side to its very crest.

Leaving the water-gap, the river descends gently southward, obliquely across the entire breadth of the Appalachian plain or valley, to where it enters the hills called "the South mountains", below Easton. This portion of its course is marked by no striking features, the surface of the country being elevated only 100 or 200 feet above it, and being, from the softness of the slates and limestones, smoothed down into rather inexpressive lines.

Below the mouth of the Lehigh the Delaware is bordered by an alternation of hills and narrow intervening valleys, the river-hills being but the ends of the intersected ridges of the low chain of the highlands of New Jersey; but from the southern edge of these hills, at Durham, the scenery for many miles southward wears a wholly different character. It is that of a table-land elevated 300 or 400 feet above the level of the river, cut on one or both sides of the valley into long ranges of perpendicular precipices or extremely steep slopes. One stretch of precipice, on the Pennsylvania side, known by the name of the "Nockamixon rocks", is an exceedingly striking and picturesque range of beetling cliffs, rising sheer for 200 or 300 feet from the brink of the river, with only a narrow roadway between them, through a length of nearly 3 miles. Some of the views from the base of these crags are almost grand, and the pictures they make with the river below are beautiful. Tufts of bushes and trees and climbing vines brighten by their green hues the rich brown tints of the rocks, to the bold faces and narrow ledges of which they lend a grace which no cliffs without vegetation ever possess.

Farther down its valley the Delaware passes, in the vicinity of New Hope, some bold ridges of trap-rock, which impart a pleasing variety to banks elsewhere, in this part of its course, comparatively tame. Passing Trenton, its borders presently put on a totally-changed aspect. Ceasing to be a gay running stream full of bushy islands and rocky reefs and rapids, it becomes a wide tidal river, rising and ebbing between shores which are in many places only low banks of sand or gravel, and in others broad, slimy marshes, covered with reeds and grass. Turning at Bordentown southwestward, the river maintains these features all the way to its wide estuary, the Delaware bay.

The Delaware crosses the fall-line at Trenton, which is the head of tide-water as well as of navigation, there being at present a navigable depth at low water of 5 feet up to this point, 133 miles from the Atlantic. Up to Philadelphia, 100 miles from the ocean, there is a navigable depth at low water of 24 feet; and the mean rise of the tides is 3.5 feet at Trenton, 6 feet at Philadelphia, and 4 feet at the "capes of the Delaware", or mouth of Delaware bay. From the report of Prof. Merriman on that part of the river between Trenton and Easton, to which I am very much indebted for valuable information, I extract the following notes in regard to the navigation of the stream,(b) which apply at the present time without much change:

The only navigation at present upon the Delaware river, above Trenton, is that of the rafts which come down during the spring and fall floods. Previous, however, to the construction of canals and railroads, the river, although difficult to navigate, was an important

a *Geology of Pennsylvania*, Vol. I, p. 47.

b *Annual Report of the Chief of Engineers*, 1873, Appendix U, page 51.

highway of commerce. The boats first used appear to have been narrow flat-bottomed scows, from 25 to 40 feet in length, which were allowed to float down with the current, and on their return up were propelled by poles. About the year 1750 "Durham" boats were introduced, so called from having been first built at Durham village, 10 miles below Easton.

These were round-bottomed boats, pointed at both stern and bow, about 60 feet long, 10 wide, and 5 deep, with a low cabin for sleeping apartment, and one aft for provisions; the center of the boat was thus left free for the load. The crew consisted of three men, two with long setting-poles, and one at the rudder, who also used a shorter pole. When fully loaded the boats drew about 30 inches; the usual load on the down trip being 20 tons, on the up trip 5 to 10 tons. The time usually required for a trip from Easton to Trenton was one day, while the return trip ordinarily occupied three days. About 1810 coal began to be carried down the river in "arks", which were simply rectangular pine boxes, usually hinged in the middle like canal-boats, and being from 50 to 80 feet long and 16 wide, and drawing 2 feet of water. These were furnished with oars for use on the reaches of the river between rapids. On arriving at the market in Philadelphia, after discharging their cargoes, the arks were taken apart, the lumber sold, while the iron-work was carried back across the country to the Lehigh, to be used again in the construction of others. The Delaware division of the Pennsylvania canal, finished in 1830 from Easton to Bristol, caused both Durham boats and arks to be but little used after that time. It is proper to mention here that the river was navigated by Durham boats as far as Lackawaxen creek, 75 miles above Easton, and probably much farther.

The completion of the Belvidere Delaware railroad, in 1857, rendered any further navigation of the river, except by rafts, unnecessary. Previous to that time, however, it was often customary during the winter season, while the canal was closed, to send canal-boat loads of coal down the river. This could, however, only be done at times of freshet, as several feet of water were required for their safe passage.

In the summer of 1851, in order to facilitate communication with Easton, and the railroad only being built as far as Lambertville, a steamboat, the "Major William Barnet", drawing, when loaded, only 18 inches, was run from Lambertville to Easton, the time occupied in making the trip of 36 miles being about eight hours.

The lumber business of the river probably began at an early date. Beginning at the lower part of its course, its inclosing banks have been stripped of their forest growth, the work continually receding up the river, until now the lumber production is confined mostly to the counties of Broome, Delaware, and Sullivan, in New York, and Wayne and Pike, in Pennsylvania. The most valuable woods—pine and oak—were first brought to market. In the year 1824, when these timbers were becoming scarce and hemlock was beginning to be cut, the lumber trade appears to have been about two-thirds as large as at present. From 1835 to 1850 it was greater than ever before, and probably exceeded the present production by one-third or one-half. The trade on the Delaware is now declining, and it is estimated that in 25 or 30 years will cease altogether. A large item in the marketing of lumber is the hauling of it to the river-banks to be formed into rafts. The forests are every year receding from the banks of the river and its tributary creeks, and the time must certainly come when the cost of transportation will be too great to allow it to be brought to market by way of the Delaware. The timber is principally hemlock; occasionally a raft is composed of ash, basswood, and hard maple, but they are rare. The timber for piles is also in part white pine. It is cut mostly in the months of May and June, drawn to the river-bank, and rafted during the next winter and floated to the market by the following spring floods.

The principal lumber depots on the upper Delaware are Delhi and Deposit, on the West branch; Walcott, on the East branch; Hancock, at the junction of the two branches; and Callicoon and Cochecton, 25 miles below Hancock. The time required to bring a raft from these points to Easton varies with the height of the water and the direction and force of the wind. In ordinary rafting-freshets of 5 to 10 feet, however, the time appears to be: from Delhi to Easton, 165 miles, 40 to 48 hours; from Walcott to Easton, 165 miles, 40 to 48 hours; from Hancock to Easton, 125 miles, 30 to 36 hours; from Callicoon to Easton, 100 miles, 24 to 30 hours; from Easton to Trenton the time is from 10 to 12 hours; so that the entire trip from Walcott or Delhi to tide-water is performed in from 50 to 60 hours, showing the mean velocity to be from 4.3 to 3.6 miles per hour.

The declivity of the river is shown more in detail by the following table:

Table of declivity of the Delaware river.

Locality.	Distance from Trenton.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Trenton, below falls	0	0			
Yardley, railroad crossing (*a*)	3	8	3	8	2. 67
Bull's island	26	74	23	66	2. 90
Easton, crossing of Lehigh Valley railroad (*b*)	54	159	28	85	3. 00
Belvidere	68	235	14	76	5. 40
Water Gap, Walker's ferry	81	301	13	66	5. 10
Erie Railroad crossing 4 miles above Port Jervis (*c*)	127	450	46	149	3. 20
Lackawaxen (*c*)	146	600	19	150	7. 90
Deposit (*c*)	212	984	66	384	5. 80
Head-waters	280	1, 886	68	902	13. 30

a This elevation was kindly furnished by Mr. Lorenz, chief engineer of the Reading railroad.
b For this elevation thanks are due to Mr. Robert H. Sayre, chief engineer of the Lehigh Valley railroad.
c These elevations are liable to considerable error, being found from the Erie Railroad profile by subtracting the *estimated* height of the rails above the water.

The flow of the river is subject to great variations, and the freshets are quite severe, as the following extracts from Prof. Merriman's report will show:

Concerning the floods or freshets of the river I have been unable to collect very exact statistics, particularly of those during the last few years. Their times of occurrence seem to be quite irregular, as well as the heights to which they rise. In general it may be said that the river is subject to three classes of floods: the ice-floods, which happen at the breaking up of the river; the rafting floods, occurring

later, from the spring rains; and the fall floods, caused by the storms of September and October, which, however, are very irregular. The heights of these floods I have only been able to ascertain for Easton and points below; at places above they are known to be similar in their character and occasionally to produce very disastrous effects.

The ice-floods are usually at Easton 10 to 20 feet in height, but on many occasions have been known to rise much higher, the "great flood" of 1841 having reached 35 feet. The great accumulation of water here is owing to the influx of the Lehigh, a very turbulent stream in time of freshet, and to the narrow steep banks between which the Delaware is confined, its width being less than 600 feet. The following description (*a*) of the effects of the flood of 1841 may perhaps here not be inappropriate:

"It becomes our painful duty to record a scene of destruction and desolation such as never before was witnessed in this section of the country. The late excessive rain, carrying with it the snow which had covered the ground, caused our streams to rise beyond all precedent. On the morning of the 8th instant they came tearing down with awful rapidity, producing waste and ruin on every side, bearing on their angry waters every kind of property, houses, barns, storehouses, fences, stacks of grain, and furniture of all descriptions. The Lehigh river, one of the most unruly of streams, has caused the greatest damage. As far as heard from, not a bridge is left spanned across it. The beautiful bridge here went about 4 o'clock on the morning of the 8th instant. The flats below South Easton, containing the collector's office of the Lehigh Coal and Navigation Company, and a small village, were completely inundated, so as to hide the dwellings; all but a storehouse was carried off. The lower part of Williamsport is almost destroyed, and both sides of the river here present but one scene of ruin. The Delaware, so remarkable for its mildness as to be called 'the silvery Delaware', also assumed a new character. It was estimated that it was 35 feet above low water, 6 feet higher than ever was heard of before. The destruction of the bridge across it was looked for during the whole of the 8th, but it stood the flood, although much injured and torn. Report has it that below this every other bridge on the Delaware is gone. The state works along the Delaware and the Lehigh company's improvements are damaged to a great extent. At many places no traces of the canal are left, the current having swept the banks away to low-water mark for great distances, and all along the line they are more or less injured."

At Bull's island this flood appears to have risen 23 feet, at Lambertville 20 feet, and everywhere to have caused very much damage. For 10 miles above Trenton the river becomes much wider, and its banks less steep, so that floods are rarely more than 10 or 12 feet. On one occasion, when the ice became jammed at Perriwig island, causing a blockade, the water was known to rise about 15 feet at Trenton.

The rafting freshets in the spring are of less rise, but of longer duration than the ice-floods; at Easton ranging from 3 to 10 feet, at Lambertville 1 to 8 feet, and at Trenton 1 to 6 feet. A very remarkable rise, however, occurred on June 8, 1862, which was 32 feet at Easton, and, next to that of 1841, the greatest flood on record.

The fall floods, which are also employed by the lumbermen in sending their timber to market, are irregular in their occurrence and the stage to which they rise. Several seasons have been known in which no floods occurred at this time, while in others, as in 1845 and 1869, they were very great. The following is a partial list of the "great floods", with the heights to which they rose, as nearly as can now be ascertained:

Name of flood.	Date of occurrence.	Height to which it rose above low water.
Pumpkin fresh	October 6, 1786	16 feet at Lambertville.
Do	1798	Not as high as last, but exact height not known.
Jefferson fresh	1801	14 feet at Lambertville.
Do	1814	Do.
Do	March —, 1832	12 feet at Lambertville.
Do	April —, 1836	14 feet 6 inches at Lambertville.
Do	April —, 1839	Do.
Great flood	January 8, 1841	35 feet at Easton, 23 feet at Bull's island, 20 feet at Lambertville, 28 feet at Lamsin's island.
Do	October 13, 1843	14 feet at Lambertville.
Do	Marc 15, 1846	17 feet 6 inches at Lambertville.
June fresh	June 8, 1862	42 feet at Easton.
October fresh	October —, 1869	Exact height not known.

The point which has been particularly forced upon my attention, in connection with this subject, is the great frequency with which floods now occur as compared with the time previous to 1835. While the preceding table is supposed to contain the record of every "great freshet" previous to 1841, it by no means shows those occurring since that date. In fact, they have become too common to be a matter of record. Previous to 1835, floods of 12 feet at Lambertville were considered very high, while 14 feet had been attained only three times within the memory of man—in 1786, 1801, and 1814. But since that time floods of 14 feet have become common, while three have occurred—1841, 1846, 1862—in which probably one-third to one-half more water has been discharged than in any previously known. This is undoubtedly to be attributed to the clearing away of the forests in the river basin.

While the floods of the river rise higher than formerly, the stage of low water seems to have been becoming lower every year. The observations of the inhabitants appear to show that in times of low water the water of the river is fully 6 or 8 inches below the most unusual low stage of forty years ago.

To recapitulate, then, this branch of my subject, I may say that the stage of the river throughout the year is ordinarily as follows: January, frozen and medium height; February and March, breaking up and high; April, May, and June, high; July, subsiding; August and September, low; October, low, but subject to high freshets; November, low—often very low; December, rising a little and freezing.

The flow of the stream would, no doubt, be much more variable than it is at present were it not for the great number of lakes which are tributary to it from northern Pennsylvania and New Jersey as well as from New York. A glance at the map will show that a large part of the drainage basin is dotted with lakes and ponds of various sizes, but generally quite small, making up somewhat in number, however, for their small size. Their influence in moderating the floods must be considerable. From the fact that they exist in such numbers, too, it would seem

a Easton *Whig and Journal*, January, 1841, quoted by Rapp, *History of Northampton County*, page 53.

to be a just conclusion that the facilities for storage are good in the greater part of the basin, and by either raising the level of some of these lakes or constructing artificial reservoirs in other places the flow might be regulated to a considerably greater extent than it is now.

As regards the actual discharge of the river, no extended series of measurements has been made. Mr. Ashbel Welch, of Lambertville, New Jersey, past president of the American Society of Civil Engineers, however, gives the discharge as varying from 2,000 to 350,000 cubic feet per second, and it is probable that the former is very near the minimum.

The rainfall over the basin of the Delaware varies from 38 inches in the upper part to 45 and over near the mouth of the stream. It is distributed through the seasons with tolerable uniformity, yet with a decided excess in the summer. The table on page 9 gives more detailed information on this point.

As regards facilities for the utilization of power, the bed and banks are as a rule favorable. The former is principally gravel, sand, and bowlders, and often rock in place, while the latter are generally high. The floods are so violent that the maintenance of dams is said to be difficult, especially on account of the great quantities of ice which the river brings down; yet, inasmuch as the only dams across the river below the forks are a few very low ones, there can hardly be said to be much experience on this point, and there seems to be no reason why the construction of secure dams should offer any particular difficulty. The rafting and fishing interests on the river are opposed to the extensive use of the stream for power, and at present no dam can lawfully be built entirely across the river. Some difficulty has been experienced from the conflict of these varied interests, as will be seen. The following are the laws of the states of New Jersey and Pennsylvania concerning dams on the river, taken from Prof. Merriman's report:

Laws of Pennsylvania concerning the navigation and improvement of the Delaware river between Easton and Trenton.

Act of March 9, 1771 (v. *Laws Pennsylvania*, vol. 1, page 322), declares that, whereas the improvement of the navigation of rivers is of great benefit to commerce, and whereas many persons have subscribed large sums of money for this purpose; therefore, etc., the Delaware and Lehigh rivers shall be common highways for the purposes of navigation.

Twenty-six commissioners are appointed to receive subscriptions and to improve the navigation by widening, enlarging, straightening, or otherwise improving the channel.

Provides a penalty of "twenty pounds good and lawful money of this province for constructing dams to impede navigation".

Act of September 20, 1783, ratifies New Jersey act of May 27, 1783, which see, page 45.

Act of March 13, 1817 (*Laws of Pennsylvania*, vol. 6, page 422), appoints three commissioners to improve the river from Foul rift (*a*) to the bridge at Trenton. Appropriates $10,000 for the work.

Act of March 29, 1819, same as New Jersey act of March 1, 1820, which see, page 50.

Act of April 6, 1825 (*Laws of* 1825, page 144), authorizes the Delaware and Raritan Canal Company to supply the said canal with water from the river, provided no injury is done to either ascending or descending navigation, but reserves the right to withdraw this privilege if, in consequence, the water of the river is lowered 1 inch, and also provides that this privilege shall cease whenever the state of New Jersey shall refuse to grant a similar right to Pennsylvania to take the same amount of water.

Act of March 26, 1826 (*Laws of* 1826, page 155), repeals last act and passes another essentially the same, except "2 inches" is substituted for "1 inch".

Act of April 9, 1827 (v. *Laws of* 1827, page 196), provides for survey of Delaware valley from Bristol to Carpenter's Point with a view of constructing a navigable communication, and provides that if after this survey the navigation can be built for $12,000 per mile it shall be done, provided the existing natural navigation shall not be impaired.

Act of April 23, 1829 (*Laws of* 1829, page 312), appoints three commissioners to meet commissioners from New Jersey to decide where and how water may be taken from the Delaware for canals and water-powers.

Act of April 10, 1832 (v. *Laws of* 1832, page 638), appoints three commissioners to ascertain facts about a certain dam of which complaint has been made, and to examine the river near Welles' falls to ascertain the best way to supply the Delaware division of the Pennsylvania canal with water.

Act of February 8, 1833, orders the above commissioners to report how the obstructions in the river can best be obviated with regard to both navigation and the use of its waters for canal.

Act of April 20, 1846, authorizes canal commissioners to erect a dam at Welles' falls to supply canal with water and to facilitate navigation between the outlet locks, provided it does not interfere with the passage of fish or Durham boats, or the raft navigation. Repealed February 9, 1848.

Act of April 4, 1866 (*Laws of* 1866, page 436), provides that, whereas the natural and artificial obstructions in the Delaware river above tide-water are such as to render the running of lumber in rafts to Philadelphia and other points extremely hazardous, causing every year the destruction of large quantities of the same, and thereby increasing its price in market, and whereas said river is the only outlet from the upper lumber region of the Delaware; therefore the sum of $10,000 is appropriated to remove these obstructions, etc. I. T. Barnes, Wayne county; John Shause, Pike county; John Fisher, Bucks county, are appointed commissioners (*b*) to improve the river at such points as they may deem best to carry out the true intent of this act, the appropriation to be expended within two years.

Act of March 7, 1872 (*Laws of* 1872, page 259), authorizes the Delaware and Raritan Canal Company, or their lessee, the Pennsylvania Railroad Company, to construct permanent wing-dams in the Delaware river, from the head of Bull's island, and also from the Pennsylvania shore to the raft-channel, not exceeding 18 inches high above common low water, and to complete and maintain the wing-dam heretofore built for the improvement of the raft navigation at Welles' falls; also to erect such temporary structures in said channels in times of low water as may be necessary to keep up the supply of water to the canal of said company, and to maintain sufficient depth of water to enable loaded boats to cross to said canal from the Delaware Division canal: *Provided*, That nothing in this act shall authorize the obstruction of the raft-channel or interfere with the running of rafts.

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a Foul rift is about 12 miles above Easton, and is a very dangerous place.

b All of these commissioners are now dead.

Laws of New Jersey concerning the navigation and improvement of the Delaware river between Easton and Trenton.

Act of May 27, 1783 (see *Revised Statutes*, 1846, page 41), declares that the river Delaware, from the northwest corner of New Jersey to the place upon the said river where the circular boundary of Delaware toucheth upon the same, is, and shall continue to be and remain, a common highway, free and open for the use of both New Jersey and Pennsylvania.

Act of November 26, 1808 (see *Revised Statutes*, 1846, page 480), provides that if any person shall erect, set up, build, or maintain any wing-dam, except such as may be put up in pursuance of any special act of the legislature, or placing any other obstruction injurious to the navigation of the river Delaware, he shall be subject to the penalty of $100.

Act of March 1, 1820 (v. *Revised Statutes*, 1846, page 547), provides that no dam, wing, or other device, creating, drawing, or using a water-power, shall hereafter be erected in the Delaware river, between New Jersey and Pennsylvania, without a view first had by three skillful and respectable freeholders in each state residing near the spot of the proposed construction; said freeholders to be appointed by the court of quarter sessions, and to report to said court. If they report favorably, and that it will not injure the navigation, the court may grant permission for the construction of the wing or dam. Penalty of not less than $500 nor more than $1,000 for violating the provisions of this act.

Act of February 18, 1829 (see *Laws* 1833, page 246): Whereas the waters of the river Delaware may, by a proper arrangement between the two states, be used for feeding canals and water-powers, to the great and lasting advantage of both: Therefore, *Resolved*, That three commissioners be appointed to meet a similar commission from Pennsylvania, to decide how and where the waters may be most advantageously used for these purposes, and their agreement, when duly ratified by the legislatures of both states, shall be binding and conclusive.

Act of April 15, 1868 (see *Laws* 1868, page 1036), authorizes the Delaware and Raritan Canal Company to make such a structure as may be necessary for the protection of their feeder at Bull's island, not exceeding 18 inches above low water, and not interfering with the raft navigation; also to complete the wing-dam at Welles' falls for the improvement of raft navigation; also to erect temporary structures at these places in times of low water, for the protection of their feeder and the canal navigation.

The latter list of laws is incomplete. The following are to be added:

Act of February 16, 1831: Trenton Delaware Falls Company incorporated. It is made lawful for the company to erect a wing-dam in the Delaware between the mouth of the Assanpink and the head of Welles' falls, and a race-way along the bank of the river; provided such dam be so constructed as not to impede the passage of rafts, fish, arks, or boats, in said river.

In virtue of this act, a dam was built at the head of Scudder's falls.

Act of February 14, 1844: Name of company changed to Trenton Water Power Company.

Act of February 19, 1847, authorizes the company to extend the race along the river, not beyond the head of Taylor's rift; provided the same shall be so constructed as not to impede the passage of fish, rafts, arks, or boats, or obstruct the free and uninterrupted navigation of the river.

The act of February 22, 1870, provides as follows:

Whereas the commissioners appointed by the state of Pennsylvania for improving the navigation of the Delaware have restored and improved the dam erected many years ago at the head of Scudder's falls by the commission duly appointed for that purpose, and connected the same with the wing-dam of the Trenton Water Power Company, whereby the navigation of said river has been greatly improved, and the supply of water to the race-way of said company been made sufficient for the various mills depending thereupon for power; and whereas the term of office of said commissioners has expired, and it is desirable that the said improvements should be maintained and protected from damage: therefore, be it enacted by the senate and general assembly of the state of New Jersey, that the Trenton Water Power Company is hereby authorized, empowered, and required to maintain and protect said dam at Scudder's falls, and the chute or passage-way thereon for rafts, boats, or fish, as now constructed, so that the navigation of the river and the supply of water to the race-way of said company may be secured and maintained.

It is evident from the above that no high dams can be built on the river, and that if large falls are anywhere utilized it must be with canals of considerable length, considering that there are no precipitous falls.

As regards accessibility, the facilities on the Delaware are of the best. From tide-water at Trenton up to Deposit, on the West branch, the stream is followed closely by railroads and canals, except for a short distance below Port Jervis, so that every point is easily reached. This very fact, however, may in some cases render the utilization of power difficult, especially on the portion of the river above Port Jervis, where the valley is narrow and the banks are often high, while the Erie railroad is on one side and the Delaware and Hudson canal is on the other, often leaving little room between them and the river for races and buildings.

Having presented the main general facts regarding the stream, I will now describe the various powers which it presents, beginning at the mouth.

The first power met with as the stream is ascended is at Trenton, the head of tide-water. A dam of timber and stone, 6 miles above the city, at the head of a rift known as Scudder's falls, raises the water about 2 feet, and diverts a portion to the canal leading to the city. The elevation above tide of the river at this point is 21 feet. The dam is about 800 or 1,000 feet long, extending in a broken line across the river, but is by no means tight, and has a chute for the passage of rafts. It is 4 or 5 feet high, and is roughly built of timber, brush, and stone. The bed of the stream is gravel and rock. This dam has been the cause of considerable trouble. It was built originally many years ago, and was improved in the interests of navigation by the commissioners appointed in 1866 by the state of Pennsylvania; but their term expiring before the dam was quite completed, the water-power company was sued by fishermen, who claimed that the dam was an injury to the navigation and fishing interests; and, although the statements regarding the case vary much, it appears that the company can not maintain or complete the dam, so that it is now in a very dilapidated condition. The canal leading from it is 7 miles long, 70 feet wide at top, and nominally 6 or 7 feet deep, but it is said to be much obstructed at its head by silt and grass. The fall at its lower end varies from 10 to 15 feet, according to the tide and the season. The privilege is owned by the Trenton Water Power Company, and power is generally leased to mills at the annual rate of $4 per square inch under a

head of 3 feet, while to some original customers it is $3, and some persons own the right to draw a certain amount of water, paying no rent to the company. The quantity of water used by the various mills was at one time measured for the company by Mr. William E. Worthen, of New York, and the prices paid have since been in accordance with that measurement. No detailed measurements are now made by the company. At $4 per square inch under a head of 3 feet, and a head and fall of 12 feet, the price is approximately equivalent to $50 per gross horse-power per annum. The mills supplied are some 15 in number, and consist of small saw-, flour, planing, woolen, and other mills, together with machine-shops, carpenter-shops, the rolling-mills of the Trenton Steel & Iron Company, and the city water-works, using in all about 360 cubic feet per second, or, with an average fall of 12 feet, about 500 gross horse-power. The mills can not obtain full capacity, however, during several months, the power sinking as low as one-half at times, so that many of the mills have steam in reserve. The leases provide for the water being out of the canal for not over two months in the year, for repairs, etc.; but the water being often very low for three months or more, such allowance is made to the mills as circumstances require. In the summer-time, then, no additional power is available with the existing dam and canal, while in winter a considerable amount goes to waste. The pond above the dam affords, of course, no storage. Freshets and ice cause little trouble to these mills.

I have measured the drainage area above Trenton and found it to be about 6,916 square miles. The theoretically available power may therefore be estimated as follows:

Estimate of power available at Trenton.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall*	10 *feet fall.*
Minimum	6,916	10–15	2,000	227	2,270
Minimum low season			2,350	267	2,670
Maximum with storage			5,000	568	5,680
Low season, dry years			2,700	307	3,070

The rainfall is given on page 9. As regards the maximum power given as available with storage, it is doubtless practically unavailable, as in the case of all large streams, on account of the enormous expense it would involve, though the facilities for storage are probably good. The power, however, could not well be concentrated into less than 24 hours, for no storage could be obtained at the dam.

Trenton is very favorably located for manufacturing, the facilities for transportation, both by land and by water, being excellent. The power is remarkable for the great length of the canal; and, in fact, I have met with no other case where the length of canal was so great in proportion to the fall obtained.

The next site above Trenton is at Lambertville, New Jersey, about 15 miles above, and at this point there are two powers. Just below the town is a rift known as Welles' falls, where the fall at low water is 14.31 feet in a distance of 4,100 feet, the river being crossed by one of the trap ridges which are so prominent in the highlands of New Jersey. For nearly a century there have been wing-dams on either side of the river at this place, leading the water to saw- and grist-mills; and in 1830 they were improved by the state of Pennsylvania "so as to furnish a supply of water to the Delaware Division canal by means of a power- and lift-wheel. In 1848 the canal was connected with the Raritan by outlet-locks and a rope ferry, and the dams were still further improved. In 1866 there was expended about $7,000 out of the appropriation of that year, and probably as much more by the canal companies, in putting in additional dams". At present the dam is of rough crib-work and stone, about 1,700 feet long and from 3 to 10 feet high, forming wings extending down stream from the left bank and up stream from the right bank, the latter wing being curved down stream at the center, leaving a chute for the passage of rafts, which, however, is closed in low water by a temporary dam. The dam is built on a rock bottom, and raises the water about 2 feet at low water at the center. The width of the stream is about 800 or 1,000 feet. When I was in Lambertville no power was used except a very small amount for raising water into the Delaware Division canal, on the right bank, but a paper-mill was being constructed on that side, at the end of the dam, to use a fall of 9 or 10 feet and a power of 165 net horse-power. The tail-race is 400 feet long and 25 feet wide, carried level from low water at its lower end.

The facilities for utilizing the total fall of 14 feet within the mile below the dam are not very good. On the right bank there are no railroad facilities, and the canal is close to the river; while on the left the railroad follows the stream closely, and on account of the high banks it is doubtful whether it would be profitable to develop much power. Nevertheless, it could be done if necessary, and in the table on page 98 I have estimated the total power available. No storage during the night could be secured, and in regard to the estimates the same remarks apply as in the case of Trenton.

The second power at Lambertville is obtained from the feeder of the Delaware and Raritan canal, on the left side of the river. This feeder is supplied from a dam on the Delaware, situated about 7 miles above the town, at the head of Bull's island, turning the water between the island and the New Jersey shore, and thence into the canal. The dam is composed of a wing from each bank, with a chute 120 feet wide between them, and is 900 feet long, or more, and 2 or 3 feet high, but raising the water only a few inches. It was built about the year 1873.

At Lambertville the canal has a lock with a lift of about 10 feet, while the upper level is about 18 or 19 feet above the river; and not only the fall of the lock, but also that to the river, is utilized for power, the following table giving information regarding the mills at present in operation:

A.—Mills discharging water to river at Lambertville.

	Approximate net horse-power.
Lambertville iron-works and machine-shop	100
Ely's flour-mill	45
Flour- and saw-mill	75
Lambertville Paper Manufacturing Company	65
B.—Mills discharging water to lower level of canal at Lambertville.	
Twine-mill	60
Amwell Cotton Spinning Company	65
McDowell's paper-mill	65
Weeden's paper-mill	65
Total power utilized (approximately)	540

All these mills can be run at full capacity during about eight or nine months, and are obliged to stop their wheels entirely during a month or more when the water is drawn from the canal; so that all but two have steam-power in reserve. There is little trouble on account of freshets in the river, but the canal, which is about 60 feet wide and 6 feet deep, has not sufficient capacity to supply much more than the wants of the mills at certain times. The power is owned by the Pennsylvania Railroad Company, lessees of the Delaware and Raritan canal, and is leased by them, the mills to obtain only the surplus water, and no fixed amount being guaranteed to them. Although the water is nominally rented at the rate of $3 per square inch under a head of 3 feet, special agreements are sometimes made, and no pains are taken to regulate exactly the quantity used. The water that is returned to the lower level of the canal is controlled by a separate water-power company, known as the Lambertville Water Power Company, the waste or flume water being carried around the lock in a canal 1,400 feet long and 18 feet wide. The company leases water to the mills at certain fixed prices, the mills to take the risk of low water themselves. These mills are probably able to run a little more regularly than those discharging the water to the river, because they do not waste the water from the canal, and are therefore less liable to be shut off in dry seasons. It may be mentioned here, in connection with power used from the feeder-canal, that between Lambertville and Trenton there are three small grist- or saw-mills taking water from the canal and discharging it to the river.

As already mentioned, the table on page 98 gives estimates of the total available power at Lambertville; but in regard to whether it is practically available, circumstances must decide. There seems to be no good reason why, if a dam could be extended entirely across the river at Bull's island, the capacity of the canal above Lambertville might not be increased so as to render a very large power available there, with a fall of 18 or 19 feet, and without interfering with the power at Welles' falls. At present, however, it is evident that scarcely any additional power is available from the canal at certain seasons. As regards transportation, Lambertville is very favorably situated.

Between Lambertville and Easton there are several shoals on the river, many of which might be used, and probably would be used, if dams could be built across the river. The table below gives information regarding them:

Falls and rifts on Delaware river between Easton and Trenton.	Distance from the railroad bridge at Trenton to the head of each rift.	Length of each rift.	Fall of each rift.	Falls and rifts on Delaware river between Easton and Trenton.	Distance from the railroad bridge at Trenton to the head of each rift.	Length of each rift.	Fall of each rift.
	Miles.	*Feet.*	*Feet.*		*Miles.*	*Feet.*	*Feet.*
Phillipsburg rift	49. 3	3, 900	5. 85	Rush rift	26. 2	300	5. 08
Whippoorwill rift	47. 0	1, 200	....	Wharford's rift	25. 5	2, 700	4. 17
Clifford's rift	45. 9	1, 500	4. 05	Little and Big Tumble falls	24. 8	4, 600	10. 37
Old Sow rift	44. 7	2, 650	4. 74	Bull's falls	22. 0	1, 800	4. 12
Ground Hog rift	43. 5	2, 000	2. 56	Eagle rift	19. 6	1, 500	....
Rocky falls	42. 5	3, 900	3. 04	Howell's rift	18. 8	2, 000	....
Gravelly rift	41. 7	800	1. 20	Bird's Point rift	17. 3	500	....
Durham falls	40. 3	500	3. 16	Limestone rift	16. 0	700	....
Old Fry rift	39. 0	100	0. 42	Welles' falls	13. 7	4, 100	14. 31
Lynn's falls	38. 0	2, 000	8. 81	Bucktail rift	12. 3	400	....
Nockamixon falls	36. 4	1, 300	4. 44	Beaumont rift	11. 3	150	....
Ferman's falls	33. 0	1, 000	5. 36	Carr's rift	9. 0	300	....
Stuhl's falls	31. 8	600	1. 50	Scudder's falls	6. 0	2, 600	....
Man-of-War's rift	29. 0	400	1. 00	Gould's rift	3. 4	1, 600	4. 69
Buttonwood rift	28. 4	700	2. 30	Trenton falls	0. 5	3, 400	7. 57
Little Howle's rift	27. 0	1, 500	8. 52				

At present there are a few small mills on the river within this distance, with wing-dams, and using falls of 4 or 5 feet, and there have been other such mills in times past. The banks of the stream are quite steep for several miles below Easton, while the railroad on one side and the canal on the other follow the river quite closely. At Easton there is a low dam extending part way across the stream, and a rope ferry, to enable boats to cross between the Morris and Essex canal and the Delaware Division canal. About 4 miles above Easton, at Wycott, there is a fall of about 8 feet in a mile, which could be utilized if necessary, and which could perhaps be made to afford a good power without interfering with raft navigation. No power is used there at present. Passing a few small rapids, where falls of up to perhaps 6 feet could be obtained, the next power, and one of the most important on the stream, is the "Foul rift", just below Belvidere. The rapids extend over a distance of about 1¾ mile, the fall at low water amounting to 22.8 feet, according to a survey made in 1847 by Caleb H. Valentine. The bed of the stream is of solid rock, and the banks are quite high, particularly on the Pennsylvania side, where a rock bluff 20 or 25 feet high extends for some distance. On the New Jersey side the banks are high along the lower part of the fall, and the railroad follows the stream closely, gradually receding from it toward the head of the shoal. The rift is divided into two parts, the upper being called the "Little Foul rift" and the lower the "Big Foul rift", and the head of the former is just below the mouth of the Pequest creek. No power is at present used at the place, but formerly there was a grist-mill on the left bank, taking water by means of a wing-dam between Big and Little Foul rifts. By using the fall of Little Foul rift and part of that of Big Foul rift it is probable that a fall of 15 or 18 feet could be rendered available, but the utilization of the total fall of 23 feet would probably be very expensive. The width of the stream at the head of the rift is about 600 feet. In the table on page 98 will be found an estimate of the total power available at this place for a fall of 23 feet.

Continuing up the river, there are said to be several places between Belvidere and Port Jervis where falls of 5 to 8 feet could be utilized, though none of them are used at present. The following rifts were named to me by persons acquainted with the river: Long rift (5 feet or thereabout), Mack's and Buttermilk, Sliding rift, Indian rift, Esp rift, Smithfield rift, Sambo and Mary, Fiddler's Elbow.

At Port Jervis, New York, some power is used, but from the Delaware and Hudson canal, and not from the river. The right to take all the surplus water from the canal-level, which is 12 miles in length, and the lowest on the canal, is owned by the estate of H. H. Farnum. The amount of water available depends, of course, upon the amount of traffic, but is always considerable, and generally quite sufficient to supply all the mills at present using power from that source, although I was told that at times even the traffic on the canal is interrupted for want of water. It may be mentioned here that the canal, which, starting at Honesdale, Pennsylvania, follows the Lackawaxen and Delaware rivers to Port Jervis, and then the Neversink and a tributary of the Hudson, terminating at Rondout, on the Hudson, is fed from the Lackawaxen, the Delaware, various tributaries of the latter which it crosses, and the Neversink; and that a number of artificial reservoirs have been constructed for the purpose by damming the outlets of lakes, of which there are so many in the neighborhood. The following are some of these lakes feeding the Neversink portion of the canal: Yankee pond, 640 acres; Lord's pond, 450 acres; Sheldrake pond, 250 acres; Wolf pond, 350 acres; Beaver Dam pond, 150 acres; McKee's pond, 250 acres; Masten pond, 100 acres. These ponds are dammed to heights of from 5 to 25 feet.(*a*)

The fall from the Port Jervis level of the canal to the river is 30 feet or over. A race 10 feet wide and 5 or 6(?) feet deep leads from the canal, and supplies the following mills: A grist- and plaster-mill and spoke factory, in one building, using in all about 95(?) horse-power, with a fall of 20 feet; a planing-mill, furniture factory, sash- and-blind factory, turning-works, etc., all in one building, using a fall of about 25 feet and 80(?) horse-power. The tail-race is from a quarter to a half mile long, with a fall of several feet. All these mills are owned by the estate of H. H. Farnum. Those leasing them state that they can obtain full capacity during only about seven or eight months, and that during a month or so no power can be obtained, the water being drawn from the canal for the purpose of making repairs. During the summer, generally, more power is available than is used, but during the winter the supply is short, probably because the canal company, which does not guarantee any special quantity of water, shuts off its feeders to a certain extent during the winter, when there is no traffic, so that almost all the water available is what flows directly into the canal from a few small streams which are intercepted by it. There seems to be no doubt, therefore, that a considerably larger amount of power could be used here if arrangements could be made with the canal company to supply the water. In summer, except in very dry seasons, when traffic is sometimes interrupted, there is generally considerable waste from this level over waste-weirs.

Above Port Jervis the Delaware has no falls or rapids of special importance, so far as I could learn, although there are rifts of minor importance, such as Saw-mill rift, 4 miles above Port Jervis; Butler's falls, a mile above; Megick falls, 4 or 5 miles still farther up; Narrow falls, 2 miles above the mouth of the Lackawaxen; Cedar falls; Cochecton falls, a little below Cochecton, and others. Regarding the amount of fall available at these places I can give no accurate information. None of them are abrupt, but they are rapids extending sometimes over distances of a mile or more, and, according to estimates of persons acquainted with the river, the falls vary from 5

a I am indebted to Mr. Charles St. John, of Port Jervis, for valuable information regarding the streams tributary to the Delaware, as well as regarding the river itself.

to 10 feet. Neither can I give detailed information as to whether these falls are easy to develop. The banks are generally high and favorable for dams, and the bed will also probably be found favorable; but, as already remarked, the closeness of the canal and railroad to the banks may in some cases leave no room for building, while the freshets are said to be very violent, and to render it difficult to maintain dams. A dam was built in 1873 or 1874 at Lordsville, 8 or 10 miles below Hancock, but the first heavy freshet carried it away, owing, however, it is said, to faulty construction. The general testimony of those acquainted with the river seems to be that, as far as location and fall are concerned, numerous fine sites for power exist, but that the heavy freshets and ice-jams, and the frequent want of building-room, constitute the principal objections to their utilization. Indeed, a glance at the table of declivity on page 91 is sufficient to show conclusively that the stream possesses a large amount of power which might be utilized if no local difficulties should be encountered. No power is at present used on this part of the stream, the only dam being the canal feeder-dam just below the mouth of the Lackawaxen, a crib-work structure about 400 feet long and 2 feet high, with a chute 160 feet wide for rafts. The height may be increased to 5 feet by means of flash-boards.

We proceed to consider the tributaries of the stream, among which will be described the two branches which unite at Hancock:

Summary of power at principal points on the Delaware river.

Locality.	Distance from Trenton.	Drainage area.	RAINFALL.					TOTAL FALL.		HORSE-POWER AVAILABLE, GROSS. (a)				UTILIZED.	
			Spring.	Summer.	Autumn.	Winter.	Year.	Length.	Height at low water.	Minimum.	Minimum low season.	Maximum with storage.	Low season, dry years.	Fall.	Horse-power, net.
	Miles.	*Sq. miles.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Feet.*					*Feet.*	
Trenton	0.0	6,916	11	13	11	9	44	7 miles	10–15	2,270	2,670	5,680	3,070	10–15	500
Welles' falls	13.7	6,820	11	13	11	9	44	4,100 feet	14.31	3,300	3,850	8,000	4,400	[illegible]	165 (?)
Lambertville (from canal)	15.0	6,750	11	13	11	9	44	7 miles	18	4,100	4,800	10,000	5,450	10 and 18	515
Foul rift	68.0	4,700	10	13	10	8	41	2 miles	23	3,000	3,500	9,500	4,000	0	0

a See pages 8 to 11.

TRIBUTARIES OF THE DELAWARE RIVER AND OF DELAWARE BAY.

Beginning at the Atlantic ocean, the first tributary of importance is the Maurice river, from New Jersey, rising in Gloucester county and pursuing a southerly course, forming the boundary line between Salem and Cumberland counties, and finally flowing through the latter to empty into Delaware bay about 20 miles north of Cape May. Its course measures in a straight line about 35 miles, and it drains a total area of about 380 square miles, lying in the eastern division of the Atlantic water-shed (see page 2). The stream is navigable as far as Millville, the head of tide-water, about 15 miles from its mouth, and the only important town along its course. The stream, like all those in southern New Jersey, is a sand-hill stream, the general character of which class of streams will be found described in my report on the southern Atlantic water-shed, and to some extent on pages 114 and 115 of this report. The first power which it offers is at Millville. A dam, built partly of earth and partly of stone, and measuring in all about half a mile in length (the stone part being 200 feet long) and 23 or 24 feet in height, forms a pond which covers, it is said, twelve or fourteen hundred acres. The dam was built in 1879, and is said to have cost $100,000. That part which is of earth is 15 or 20 feet wide on top, with flat slopes on each side, while the stone part is rectangular in section, with four buttresses on the face, 8 feet wide and 20 feet high, stepped off in front. The bed of the stream in front of the stone dam is protected by an apron of logs. From the pond a race 1,500 feet long, 40 feet wide, and 7 feet deep leads to the mills, where the fall is 24 feet at mean tide. The following list gives the mills now running, with the net power used: Water-works, 40 horse-power; grist- and flour-mill, 40 horse-power; blacking-mill, 50 horse-power; foundery, 60 horse-power; bleachery, 100 horse-power; cotton factory, 400 horse-power—making a total of 690 horse-power. Full capacity can be obtained during eleven months, and three-quarters during the remaining month; but this is by drawing down the water in the pond at all seasons, so that no water is wasted. In addition to the water-power, steam-power is used continually in the cotton factory and part of the time at the bleachery, to the extent of 150 horse-power in each. All the mills are owned and operated by the Millville Manufacturing Company. The power is one of the best and largest in southern New Jersey, and the facilities for transportation are good. Boats drawing 7 feet come up to the factory, but a great desire is expressed to have the navigation of the stream improved so that larger craft, which now have to be partially unloaded 2 miles below the town, can ascend.

There are no large powers on the stream above this point, so far as I could learn, although on the stream and its tributaries there are some small mills. It is said that about 6 miles above Millville a fall of 10 feet could be obtained by damming, affording a good power, with quite a large pond. The declivity of the stream is very gradual, and the bed sand.

The next tributary worthy of mention is Cohansey creek, New Jersey, which rises in Salem county and flows south into Cumberland county, flowing by the town of Bridgeton, which is the head of navigation and of tide-water, and finally nearly west into the Delaware. It is a small stream, draining only about 100 square miles, and resembles the Maurice river in general character. Its only power of importance is at Bridgeton, up to which point (15 miles) there is a navigable depth of 7 feet at low water. An earthen dam about a quarter of a mile long and 11 or 12 feet high forms quite a large pond, and from it a race a mile long leads to the town, where a fall of 14 or 15 feet is used at mean tide. The mills supplied are: A flour-mill, owning the right to a certain quantity of water, and using a fall of 12 feet, with 25 or 30 horse-power, and the Cumberland Nail & Iron Company, using a fall of 14 feet, and running a nail factory, foundery, machine-shop, and blacksmith-shop continuously by water-power, about 90 horse-power being used, while another nail-mill of the same company uses about 60 horse-power part of the time, steam being used for several hours every day during high tide. These mills can obtain full capacity all the time, at nearly all seasons, by drawing down the water in the pond during the day-time. There are several ponds on the stream above this, so that the flow is remarkably constant, and there is no trouble with freshets or with ice. There are no other large powers, however, and only a few small grist- or saw-mills. On a tributary to the Cohansey which flows through Bridgeton a pond called East lake is used to run a grist- and saw-mill and the city water-works, the fall being 19 feet; and formerly a woolen-mill was run from the same pond, suffering, however, for want of water. In fact, many of the small streams in this part of the state are dammed at various places, affording excellent small powers, with considerable storage.

The other tributaries from New Jersey below Trenton (the fall-line) are similar to those just described, though with no large powers. The largest is Rancocas creek, a stream utilized to a considerable extent. On the north branch there are some grist-mills, and the works of the H. B. Smith Machine Company, at Smithville, using a fall of 8 feet and about 100 horse-power to run their various mills. Full capacity can be secured all the time, probably by drawing down the water in the pond. The site is only 2 miles above Mount Holly, which is the head of tide-water. The head of navigation is Centreton, 7.6 miles from the mouth, and the navigable depth up to this place is 4.5 feet at low water. Assanpink creek, emptying at Trenton, runs, besides a number of grist-mills, the rubber works of Whitehead Brothers, with a fall of 7 or 8 feet, and 80 horse-power during six months, by drawing down the water in the pond. At Trenton the same stream runs Wilson's woolen-mill.

Passing to the west side of the river, the tributaries from Delaware, with one exception, call for no notice. Those below Wilmington are small sand-hill streams, and their power utilized is tabulated beyond. Christiana creek, however, which empties near Wilmington, has considerable power, and its tributaries lie partly above the fall-line. The main stream, which has its sources in both Maryland and Delaware, lies entirely below the fall-line, and is essentially a sand-hill stream. It has a navigable depth of 12 feet at low water up to Wilmington, 12 miles from the mouth, above which it runs a number of small mills whose power is given in the appended table. White Clay creek, one of its tributaries, has more fall, and rises in Pennsylvania, above the fall-line. It runs a number of grist-mills, besides paper-, cotton-, and woolen-mills, and is in fact one of the best-utilized streams in the neighborhood. The Kiamensi woolen-mill, at Stanton, the head of tide-water, uses a fall of from 9 to 16 feet, and 55 to 75 horse-power, holding the water at night; just above is a site not used, formerly occupied by the "Harmony" flour-mill, with a fall of 8 feet; then a flour-mill with a small power; then a site formerly occupied by the Roseville cotton-mill, with a fall of 12 feet; and then, at Newark, Dean's woolen factory and Curtis & Brother's paper-mill, the former with a fall of 10 feet, and 50 horse-power during eight months, and the latter with a fall of 12 feet, and 75 or 80 horse-power during three months. The flow of the stream is very variable, and is said to be much less constant than in former years. Red Clay creek, a tributary of White Clay creek, is a similar stream, and runs mills of various kinds, details regarding which are not necessary. The only remaining tributary of the Christiana which is worth naming is the Brandywine, which rises in the northern part of Chester county, Pennsylvania, and flows south to join the Christiana just below Wilmington. This stream is the most important water-power stream in the vicinity. The first power is at Wilmington, where there are two dams. The lower, 200 feet long and 6 feet high, supplies the following mills: On the south side, a grist-mill, with 6 or 8 feet fall, and 30 horse-power; and on the north side, one wheel in a flour-mill run principally from the upper dam. Full capacity can be secured during only six months, because the only water available is what flows over the dam above. The upper dam is about 200 feet long and 5 feet high, and races a mile long lead the water by the first dam, supplying the following mills: On the north side, four corn- and flour-mills; and on the south side, a corn-mill, a flour-mill, a machine-shop, and the city pump-works. The fall used is 19 or 20 feet at mean tide. The total power used is uncertain. There were not long ago four other corn-mills on the south side, which were destroyed by fire. These mills can secure full capacity during only from six to nine months, and the city water-works have steam-power in reserve. The bed of the stream for some miles above tide is rock and gravel, and, like the banks, favorable for dams, but the storage obtained is small, on account of the rapid fall. This shoal or rapid is probably at the place where the stream crosses the fall-line—the head of tide-water. The drainage area being about 238 square miles, I should estimate the power at about 5 gross horse-power per foot when at its minimum, and 10 horse-power in the low season of ordinary years, the latter figure giving, therefore, a power of 200 horse-power, gross, with a fall of 20 feet. The flow of the stream is quite variable, and there are no lakes in the basin; but the rainfall is large, and favorably distributed, being as follows: Spring, 12; summer, 13; autumn,

12; winter, 10—year, 47 inches. The four mills that were burned had together eight pairs of stones, and used a fall of 20 feet. All the powers at Wilmington are owned by the owners of the mills, and the distribution of water is governed by old agreements and contracts. It appears that there are seven rights on the south side, from the upper dam, each entitled to about 155 square inches under a head of about 3 feet. The total power used on the north side is about 75 or 80 horse-power, and is all owned by one person.

For the next 5 miles above Wilmington the fall of the stream is large, amounting, it is said, to over 200 feet, while in the 8 succeeding miles, above Rockland, it is stated at only 20 or 30 feet. Between the two Wilmington dams there was once a third dam, which it was intended to raise so as to do away with the upper dam, but nothing now remains of it. The next mill above Wilmington is the Augustine paper-mill of Jessop & Moore. The dam is 160 feet long and 6 feet high, built of stone in 1868, the previously-existing timber dam having been carried away. The fall is 10½ feet, and 280 horse-power is used, with, in addition, steam power to the extent of 570 horse-power, running all the time. The full capacity of the wheels can be secured during only four months of the year. The next mill is the cotton-mill of J. Riddle, Son, & Co. The dam, which is principally of stone, is 225 feet long and 8 or 9 feet high. The fall used is 15 or 16 feet, and the power is 300 horse-power, which, however, can be obtained during only about eight months, reserve steam-power being used when the water is low. The dam was partly carried away in the great freshet in October, 1877. Above this is Bancroft's cotton-mill, with a stone dam 170 feet long and 11 feet high, a race of a quarter of a mile, and 230 horse-power, with a fall of 22 feet, full capacity being secured nearly all the time. Then come the Dupont powder-mills, there being five dams in succession, the entire fall being utilized. The dams vary in length from 100 to 125 feet and in height from 6 to 12 feet, and the total fall utilized is 59 feet. The total power used is stated at about 500 horse-power, which can be secured nearly all the time. Besides supplying power to the powder-mills, these dams run a grist-mill, four cotton- and woolen-mills, a wooden-keg factory, and an iron-keg factory, all belonging to the firm of E. I. Dupont, De Nemours, & Co. It is hardly worth while to particularize further regarding the mills on the stream. It is utilized to its very head by paper-, grist-, and woolen-mills, iron-works, etc., and is in all respects an excellent stream for power. Its tributaries, too, as Buck run and Doe run, are well utilized by mills of various kinds, and, although some power still remains unused, most of the good sites are occupied. Between Rockland and Chadd's Ford there is said to be an available fall of 20 feet on the main stream not utilized; at Smith's bridge another fall of 10 or 12 feet is said to be available, where there was once a paper-mill; at North brook there is said to be 7 or 8 feet, formerly used; and there are other similar but smaller sites. There are, however, no precipitous falls, the declivity of the stream being gradual, if we may except the lower few miles. The table on pages 114 to 121 gives the utilized power on the stream.

Between Wilmington and Philadelphia there are small streams similar in character to the Brandywine, crossing the fall-line just above their mouths, and utilized to a considerable extent by mills of various kinds. Such are Cobb's, Crum, Derby, Ridley, and Chester creeks. Derby creek drains about 50 square miles, and is well utilized by grist- and saw-mills, woolen- and cotton-mills, and others. Cobb's creek, one of its tributaries, has a number of mills of various kinds. Crum creek drains about 38 square miles, and Ridley creek about the same, while Chester creek is the largest of all, draining 70 square miles. On Ridley creek and Chester creek there are numerous mills. Many of them are quite large and use principally steam-power, for in dry weather there is but little water-power available. The ponds on these streams are often large enough to hold the water during the night, even in winter and spring, so that considerable power is obtained, considering the small size of the streams. The falls are often large and the dams high. It may be said that almost the entire power of these streams is utilized, for no good sites remain unoccupied, and the mills utilize nearly the entire flow, some of them having wheels of sufficient capacity to utilize even the freshet-water.

THE SCHUYLKILL RIVER.

The Schuylkill river may be called the principal affluent of the Delaware. Rising in Schuylkill county, Pennsylvania, it pursues a southeasterly course, passing through Berks, and then forming the boundary between Montgomery on the north and Chester on the south, to flow finally through a part of Montgomery and through Philadelphia to join the Delaware river. It flows by a number of important towns, such as Pottsville, Reading, Pottstown, Phœnixville, Norristown, and Conshohocken, and is navigable for sea-going vessels only up to Fairmount, a distance of 8.4 miles from its mouth, where the first dam is built across the river. Above that point it is navigable for river boats as far as Schuylkill Haven, the navigation being controlled by the Philadelphia and Reading Railroad Company, lessees of the Schuylkill Navigation Company; and it was at one time navigable as far as Mount Carbon, the works above Schuylkill Haven having been abandoned a few years ago on account of the washing in of waste from mines, and the scarcity of water. The navigable depth at low water is 24 feet to Girard point (1 mile), 20 feet to Gibson's wharf (4.7 miles), and 12 feet to Fairmount. The mean rise and fall of the tides is 6.1 feet. The drainage area of the stream is stated differently by different authorities. Mr. H. P. M. Birkinbine gives it as 1,942 square miles, and Mr. E. F. Smith, chief engineer of canals, quotes it as 1,800 square miles. My own measurement gave 1,912 square miles, and as it is intermediate between the other two, I have assumed it correct. A table giving the drainage areas above certain points, as well as those of the most important tributaries of the stream, is given on pages 113 and 114.

The head-waters of the Schuylkill are in the mountainous coal-bearing regions of Schuylkill county, but after flowing for a distance of 25 or 30 miles, receiving large accessions, the stream enters a more highly-cultivated country and the slope becomes more gentle. The following table will show the fall of the stream:

Declivity of the Schuylkill river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Fairmount	8.4	0			
Pawling's dam	30.0	66.63	21.6	66.63	3.1
Kissinger's dam, Reading	70.0	204.52	40.0	137.89	3.4
Blue Mountain dam, Port Clinton	91.5	389.96	21.5	185.44	8.6
Dam No. 11, Landingville	100.0	471.66	8.5	81.70	9.6
Dam No. 7, Schuylkill Haven	105.0	509.36	5.0	37.70	7.5
Dam No. 4, below Mount Carbon	109.0	583.96	4.0	74.60	18.6
Dam No. 1, Port Carbon	112.0	618.76	3.0	34.80	11.6

That part of the stream above Port Carbon has a still greater slope. Although the figures in the above table, with the exception of the elevations, can not pretend to absolute accuracy, they show that the river has a very rapid fall. As already mentioned, the stream is controlled by the Reading Railroad Company, and is navigable by means of locks, dams, and canals as far as Schuylkill Haven. Between this point and the mouth there are 24 dams, and above these are six others, not now used for navigation. Statistics of these dams are given on page 103.

The rainfall over the basin of the Schuylkill is about 45 inches, of which 12 fall in spring, 14 in summer, 10 in autumn, and 9 in winter. The flow of the stream is not so variable as that of most streams of like size in this part of the country, probably on account of the favorable distribution of the rainfall, the numerous artificial reservoirs in the shape of the pools of the canal-dams, and the numberless mill-ponds on the tributary streams. There are no lakes of any consequence in the basin, but there are three artificial reservoirs, constructed for the benefit of the navigation, as follows:(*a*)

Silver Creek reservoir, on the Broad mountain, 9 miles from Pottsville, 1,500 feet above tide-water: Length of mound at top, 1,157 feet; maximum height of mound dam, 42 feet; depth of water on outlet-pipes, 37 feet; ponds, 58 acres; contents, 42,780,500 cubic feet; drainage area, 1.275 square miles.

First, or *Lower Tumbling Run, reservoir*, near Mount Carbon: Above tide, 647.54 feet; length of mound, 418 feet; maximum height of mound, 47 feet 6 inches; depth of water on pipes, 41 feet 6 inches; ponds, 25.57 acres; contents, 25,546,512 cubic feet.

Second, or *Upper Tumbling Run, reservoir:* Above tide, 694.25 feet; length of mound, 540 feet; maximum height of mound, 63 feet; depth of water on pipes, 57 feet; ponds, 31.45 acres; contents, 39,856,612 cubic feet; drainage area, 6 square miles.

These reservoirs can be filled twice each season from the rainfall on the drainage area. They are of use only to supply the upper part of the navigation, and of no use for supplying the mills near Philadelphia, the distance being about 100 miles. The Pottsville Water Company has also two storage reservoirs, the higher and larger on Eisenhuth's run, 1,700 feet above tide, with a capacity of 52,000,000 cubic feet. In regard to the actual flow of the stream no continuous measurements have been made, but the minimum flow has been estimated several times, as follows:

In 1816 measurements were made by a committee of the Schuylkill Navigation Company, at a time when the river was said to be as low as at any previous period for twenty years, giving a flow of 771 cubic feet per second. About 1825 it was estimated at 680 cubic feet per second. In 1867 it was stated at 617 cubic feet per second. In 1874 the flow was measured by Edwin F. Smith, civil engineer, now chief engineer of canals, by gauging the water used by the mills at Manayunk, and adding to the quantity so found the amount consumed in lockage and the estimated leakage. He gave the minimum flow as about 380 cubic feet per second. In the report of the chief engineer of the Philadelphia water-works for 1876 it is stated that the flow of the Schuylkill in the summer of that year, as calculated from the amount used by the wheels, pumps, and locks, averaged 230,788,838 gallons per day for a period of 45 days. In 1878, Mr. H. P. M. Birkinbine, formerly chief engineer of the Philadelphia water-works, stated that he had estimated the minimum flow at 310 cubic feet per second, by adding together the amount pumped at Fairmount, the amount used to run the wheels, the lockage, and the estimated leakage. In 1880, Mr. Charles G. Darrach, civil engineer, gave the approximate figures which we have quoted on page 10.

a For these figures, as well as many others relating to the Schuylkill river, I have to thank Mr. E. F. Smith, of Reading, chief engineer of canals, Reading Railroad Company.

The freshets on the stream, notwithstanding the considerable storage, are quite severe, and seem to have been gradually increasing in violence. Since the completion of the Fairmount dam, in 1821, the overfall of which is oblique, with a length of 1,112 feet, the water rose once to a height of 11 feet 5 inches on the dam, and it has several times reached a height of 10 feet. The increase in the violence of the freshets, and the decrease in the minimum flow which would seem to be indicated by the measurements which have just been referred to, are due, without doubt, principally to the destruction of the forests on the drainage basin.

In connection with the problem of the future water-supply of Philadelphia, the question of increasing the minimum flow of the river by the construction of artificial reservoirs has several times presented itself, and Mr. James F. Smith has proposed for the purpose "to build, in the valley of the Schuylkill, 14 new dams and 3 new reservoirs, and also to use 8 of the dams and the water of the existing navigation above the Blue mountain, as well as the waters of the present reservoirs at Tumbling run and Silver creek", affording a total storage capacity of about 614,337,000 cubic feet, or sufficient to add about 230 cubic feet per second to the flow of the stream during 30 days, supposing the reservoirs to be filled and emptied but once. The cost of this plan is not known, but it is considered that if applied to pumping water by water-power, the plan would be more expensive than pumping by steam, so that it is not favorably regarded as a means of increasing the water-supply of Philadelphia; and it seems scarcely probable that it would pay as a means of creating water-power to be used in manufacturing. The valley of the Schuylkill, however, may be said to be favorable for reservoirs, and a large amount of storage could be secured if desired. A reservoir has been proposed on Perkiomen creek (a tributary emptying 3 or 4 miles below Phœnixville) for the purpose of increasing the water-supply of Philadelphia; and it is stated that a dam 70 feet high would flood 2,000 acres, affording a storage capacity of over 20,000,000,000 gallons. This would suffice to double the minimum flow of the Schuylkill for a period of 80 days. Its cost is stated at $800,000. All plans for extensive storage must of necessity be expensive, and it is not probable that they will be resorted to as a means of increasing water-power alone.

The first power on the Schuylkill is at the Fairmount dam, where power is used by the city water-works for pumping water into the reservoirs. The dam was originally built between April 19, 1819, and July 25, 1821, by Ariel Cooley, of Chicopee, Massachusetts, and the cost of dam, locks, head-race, etc., was $150,000. The river is about 900 feet wide, and the bed, for a quarter of the width, on the east side, was rock covered with 11 feet of mud, while for the remainder of the width it was rock at a maximum depth of 30 feet, and bare at low water on the west side. From the east side a mound dam 270 feet long and 15 feet above the overfall, built of earth, quarry spawls, and stone, was carried diagonally up stream, terminating in a strong pier of timber filled with stone. At this point the bottom is mud, 30 feet below low water. From this point the overfall was carried diagonally up stream, and was 1,204 feet in length, terminated on the west by a pier and guard-locks, from which the canal extends 569 feet down stream, to two outlet-locks. The overfall was built of crib-work founded on the rock. In some places the structure of the dam is over 30 feet high, while on the west the foundation is bare at low tide and the height of the dam is less than 9 feet. The timber cribs of which this original dam was built soon became decayed above low water, and were rebuilt from that point in 1842–'43. In 1865–'66 a new crib was sunk in front of and against the old dam for a distance of 450 feet, across the deep water, to secure the foundations. This crib extended 30 feet in front of the old dam, and after being filled with stone it was decked with white-oak timber 10 inches thick. It extended only up to low water, and was finished in 1867, having cost $41,271 29. A new dam was begun June 1, 1872, immediately in front of the old one, founded on the rock at the west end, and, at the east, on the cribs sunk in 1865. Additional cribs were also sunk in front of those of 1865, to strengthen them. The length of overfall is now 1,112 feet, and the entire length of dam 1,600 feet, including overfall, mound-dam, arches of forebay (104 feet), and piers (22 feet). The race leading to the wheels is about 250 feet long, 90 feet wide, and 6 feet deep below the crest of the dam. The fall from the top of the flash-boards is 8.7 feet at high tide, 16.37 feet at low tide, and 12.53 feet at mean tide. The comb of the old dam, below which the water can not legally be drawn, is 22 inches below the flash-boards. The power is used to drive 7 turbine wheels and 1 breast-wheel, with which the pumps are connected, and the water is pumped into two reservoirs—the Fairmount reservoir, 87.58 feet above the flash-boards, and the Corinthian reservoir, 113.58 feet above the same level. The amount of power used varies greatly according to the season. The full capacity of the pumps is stated at 36,000,000 gallons per day,(*a*) which, with an average lift of 110 feet, including friction, corresponds to a power of 693 horse-power. The full capacity of the wheels is stated at 966 net or effective horse-power. This power, however, can be obtained during only a small portion of the year, the lack of power being principally due to low flow, the trouble from freshets being slight. In 1879 the average pumpage during 12 consecutive days during the low season was only 8,000,000 gallons per day, corresponding, with a lift of 110 feet, to 154 horse-power in the pumps, and about 192 in the wheels.(*b*) The pumpage by water-power in this year was less than in any year since 1865, and the daily average was only 19,950,213 gallons, while during the months of October and November it was only 9,357,842 gallons. There were but 89 days in this

a *Report of the Chief Engineer*, 1879. I am indebted to Mr. Charles G. Darrach, principal assistant engineer of the water department, for much valuable information, and for reports, etc.

b In the report of 1879 it is stated that to "increase this minimum to an average of 18,000,000 gallons, by building impounding reservoirs at the head-waters, will cost not less than $500,000".

year on which water flowed over the flash-boards. Some idea of the proportion of the total power used in different months will be obtained from the following statement, taken from the report for 1879, showing the average number of gallons pumped per day for each month in that year: January, 23,602,706; February, 23,311,722; March, 24,913,564; April, 25,199,519; May, 29,519,156; June, 22,919,996; July, 12,630,113; August, 18,873,656; September, 15,570,215; October, 9,198,624; November, 9,517,060; December, 24,146,228.

It is evident from the above that nearly all the available power at Fairmount is utilized. Although a considerable quantity of water flows over the flash-boards, it could not be saved except by reservoirs at the head-waters, or by increasing the capacity of the wheels and pumps, which is already much in excess of the power available in dry seasons. It is hardly worth while to attempt to make an estimate of the power available in different months, for the whole question of the power at Fairmount is intimately connected with that of the water-supply of the city and with the navigation on the stream. It is sufficient to say that into the Fairmount pool is discharged the total flow of the river, amounting to 245,000,000 gallons, or thereabout, when at its minimum, and that this flow is used for the supply of the city, for driving the water-power pumps, and for lockage. With the exception of a small amount obtained from the Delaware river, the entire water-supply of Philadelphia is drawn from the Schuylkill. Allowing nothing for contingencies, the total capacity of the pumping machinery was, in 1879, about 113,000,000 gallons per day, of which 36,000,000 were by water-power. When the consumption is greatest, however, only about 60,000,000 gallons are so available. The average maximum daily consumption in 1879, for periods of a week each, was about 60,000,000 gallons, and the daily average for the year about 48,000,000 gallons. What water remains above that necessary for the city may be applied to pumping by water-power and to lockages. The quantity required for the latter purpose is not large, the lockage and leakage being estimated by the commission of engineers appointed in 1875 at 7,000,000 gallons per day. Although at some seasons considerable additional water-power is available, yet when we remember that in 1879, during a period of seven months, water ran over the flash-boards only sixteen days, it will be evident that the additional power which could be secured would not be available during many months. It is said, however, that the present turbines are defective, and that by putting in more efficient ones the power might be considerably increased. Their efficiency is said to be but 60 per cent. The commission of engineers of 1875 recommended the improvement of the old wheels, and the construction of two new ones, one to replace the breast-wheel.

The power on the Schuylkill above Fairmount is controlled by the Reading Railroad Company, and, as has already been mentioned, there are a number of canal dams on the stream, statistics of which are given in the following table:

Lengths and dimensions of dams on the Schuylkill river.

No.	Locality.	Height of fall.	Length of overfall.	Length of pool.	Width of pool.	Area ponded.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	
1	......	......	......	......	......	......	Abandoned.
2	......	......	......	......	......	......	Abandoned.
3	Mount Carbon	......	......	......	......	......	Not used for navigation—filled up with sand and *débris*.
4	Port Carbon	......	......	......	......	......	
5	Second Mountain	......	......	......	......	......	
6	Above Schuylkill Haven	......	......	......	......	......	
7	Schuylkill Haven	10.00	351	......	......	......	Small pools—not much larger than the canals.
8	Below Schuylkill Haven	......	251	......	......	......	
9	......	......	......	......	......	......	
10	Landingville	......	270	......	......	......	
11	....do	6.50	295	......	......	......	
12	Auburn	7.30	348	......	......	......	
13	....do	6.40	128	......	......	......	
14	Above Port Clinton	17.52	243	12,540	203	58.438	
15	....do	15.00	265	5,280	205	14.543	
16	Blue Mountain	24.90	434	8,527	290	56.768	
17	....do	4.83	476	3,800	230	20.006	
18	Leesport	8.50	242	5,280	240	29.090	
19	Above Reading	14.81	451	19,120	280	122.900	
20	....do	8.37	425	9,240	380	80.606	
21	....do	8.71	317	6,072	300	41.818	
22	Reading	14.00	296	5,914	300	40.730	
23	Below Reading	7.02	325	13,490	430	133.166	
24	....do	18.80	423	13,041	375	112.267	
25	Limerick	6.50	342	10,348	430	102.149	
26	Phœnixville	8.40	376	18,770	425	184.445	
27	Pawling	4.30	329	9,979	430	98.507	
28	Port Kennedy	4.83	495	20,929	450	216.208	
29	Norristown	9.00	898	17,635	665	269.221	
30	Conshohocken	7.75	527	14,757	510	172.774	
31	Manayunk	16.75	523	23,100	485	257.197	
32	Fairmount (Philadelphia)	13.00	1,200	30,993	600	426.900	

It has several times been proposed to increase the water-power at Fairmount, and several methods have been advanced: First (and this method is said to be followed as far as practicable), to run the wheels during low tide, when the fall is great, drawing down the water in the pond. The storage available is a depth of 22 inches over a pond covering some 480 acres, giving nearly 40,000,000 cubic feet, or enough to store the minimum flow for over 24 hours, and thus allowing the power to be considerably increased. Second, by storage reservoirs; but this plan is so expensive that it does not find much favor. Third, by raising the Fairmount dam. It is said that the dam could be raised 4 feet, increasing the power 36 per cent.

The drainage area above Fairmount is about 1,880 square miles, according to my measurement. The rainfall is as stated on page 9. Mr. Darrach's figures regarding flow are given on page 10.

At some of these dams and along the canal at various points a certain amount of power is available, and a considerable quantity is now rented by the company, the renting of power, however, being incidental and subservient to the boating interests. The charter of the Schuylkill Navigation Company does not allow water-power to be sold or leased except out of the surplus water of the river after the navigation is fully supplied. The company, therefore, does not guarantee steady power, renting only the surplus water beyond what is needed for navigation; but the quantity leased is so regulated that a steady power can be maintained. The following table gives the statistics of power at present used on the stream:

Water-powers along the Schuylkill river.

No.	Name and kind of mill.	Location.	Number of square inches deeded or leased, under various heads.	Rental per annum.	Motive-power.	Diameter and name of wheel.	Depth of head-water in feet.	Head and fall acting on wheel, in feet.	Quantity of water discharged in cubic feet per minute.	Effective power of wheels, approximately.(a)	Auxiliary steam-power.
1	Heft & Ogle, Dexter cotton-mills and dye-works	Manayunk	150 10	$450 00 Free.	Overshot	18 feet 6 inches	4.329	....	804.79	20.90	60
2	A. Campbell Manufacturing Company, cotton	....do	b 380 610	1,218 74 3,660 00	Turbine Overshot	48-inch Leffel 16 feet 11 inches	3.833	21.40	4,010.00 3,282.00	123.40 75.20	530
3	McDowell paper-mill	....do	100 650	313 12 4,875 00	Turbine	52-inch Jonval	....	21.80	3,037.50	86.60	125
4	Robert Patterson & Co., cotton	....do	2,556	11,130 34	3 turbines 1 turbine	48-inch Leffel 20-inch Leffel	......	20.80	11,918.82	354.70	......
5	Eagle mill, cotton and woolen	....do	100	500 00	Overshot	18 feet	3.540	....	462.52	11.10	75
6	James B. Winpenny, cotton	....do	575	3,300 00	2 overshots	18 feet	3.681	....	2,286.36	55.09	......
7	Wabash mills, cotton and woolen	....do	100	373 87	Overshot	18 feet	3.909	....	488.64	11.85	60
8	Joseph Stelwagon's Sons, brown roofing-paper.	....do	142	1,050 00	....do	17 feet	4.583	....	711.12	16.64	60
9	Thomas Schofield, woolen	....do	300	1,882 00	2 overshots	17 feet	3.384	....	1,376.82	31.24	......
10	John & James Dobson, carpet	....do	c 256.7	915 00	1 overshot	16 feet	2.704	....	983.88	20.59	......
11	Martin & William H. Nixon, paper	....do	1,692	8,194 00	2 turbines	40- and 48-inch Leffel	....	19.40	6,855.17	192.09	300
12	American Wood Paper Company	....do	1,897	10,060 00	3 turbines	35-, 40-, and 48-inch Leffel.	....	19.00	8,578.00	230.90	200
13	J. Wood & Brother, rolling-mill	Conshohocken	1,932	1,600 28	2 turbines	54-inch Leffel	....	7.75	7,223.00	79.29	......
14	Hamilton Maxwell, cotton	... do	1,009	639 00	....	56-inch Leffel	....	7.75	3,788.00	41.58	60
15	Wyoming mill, cotton (d)	Norristown	....	....	2 turbines	56- and 96-inch Leffel	....	9.00	....	200.00	......
16	C. Heebner, flour-mills (d)	....do	....	....	1 turbine	30-inch Leffel	....	9.00	....	30.00	......
17	Bridgeport flour-mill (e)	Bridgeport	....	808 00	3 turbines	2 40- and 1 43-inch Leffel.	....	9.00	3,174.60	40.47	......
18	The Phœnix Iron Company	Phœnixville	400	400 00	2 turbines	48-inch Parker	....	9.00	....	49.00	......
19	Krick's flour-mill (e)	Reading	....	626 00	2 turbines	42-inch Parker	....	6.00	3,686.95	31.30	......
20	Kernsville flour-mill (e)	Kernsville	....	....	....	....	....	11.00	1,282.66	19.98	......
21	Orchard flour-mill (d)	Pottsville	....	....	1 pitchback	....	3.000	9.00	2,010.00	25.60	......

a Power not measured by dynamometer. *b* 810 extra. *c* 70 inches free. *d* These water-rights are owned by the mill-owners.
e These mills are owned by the Philadelphia and Reading Railroad Company. The rent includes the power.

The company leases power by the square inch of aperture under a head of 3 feet, measured from the center of the aperture to the datum surface of the canal. (The water is kept several inches above datum.)

Standard apertures are of cast iron, with edges not exceeding 1 inch in thickness, without ajutage. In computing discharge of water a coefficient of 0.70 is allowed, and a discharge per square inch of 4.05 cubic feet per minute. The prices charged for water-power are as follows: To mills using power 10 hours per day, $6 per square inch per annum; to paper-mills running full time (24 hours), $7 50 per square inch per annum.

Only one instance has occurred when there has been any lost time on account of a scarcity of water, and that was in the year 1880. The cotton-mills lost a total of 96 hours' time in July, August, September, October, and November; and the paper-mills 62 hours of day runs and 39 nights during the same period. Changes have been made since December, 1880, that will obviate any loss of time by the

mills in future. In renting power to mills using turbine wheels the gauging is done the same as at Lowell, Massachusetts, and the discharge per minute divided by 4.05 gives the number of square inches under a 36-inch head. Turbine wheels are run under the full head and fall without the intervention of an aperture and gate.(a)

Between Norristown and the mouth of Perkiomen creek there are two canal dams, but the falls are too low to be available for power, and the locations are not safe from floods. Above the Perkiomen there is surplus water enough only for the small mills, Nos. 17, 18, 19, and 20, although a small amount of water is always wasting over all the dams except the Norristown and Flat Rock dams, where flash-boards are used so as to save all the water in dry weather for the mills and navigation. Very little power is used directly from the river, *i. e.*, not from the canal or the canal dams. Below Reading there is only one mill so supplied, with a fall of about 4.5 feet and 15 horse-power, and above that place there are only a few small mills. No good sites for power were brought to my notice. Above Schuylkill Haven the six navigation dams which have been abandoned could probably be used for power, but the stream is very small; besides, the ponds are full to overflowing with coal-dirt and sand carried down by the streams on which the collieries are situated, in the Schuylkill coal regions. On the head-waters of the stream in the mountains there are large falls available, but with little water.

THE TRIBUTARIES OF THE SCHUYLKILL RIVER.

The various streams flowing into the Schuylkill are utilized to a large extent by mills of various kinds, but very little information could be collected regarding them. Mill creek, from Montgomery county, drains about 9 square miles, and is well utilized. Gulf creek drains 7.5, East Valley creek 21, Wissahickon creek 78, Plymouth creek 8, and Stony creek 16 square miles. They are all well utilized, their slopes are gradual, and their flow is quite variable. The main tributary of the Schuylkill is the Perkiomen, which drains about 345 square miles, rising in Berks county, and flowing south through Montgomery, joining the Schuylkill 3 miles below Phœnixville. The main stream, with its tributaries, runs a large number of mills. The fall does not seem to be very great, averaging only about 4 feet per mile for the lower 11 miles. The declivity is gradual, and the falls at the mills are not large. No good sites not occupied were mentioned, though there are probably many small ones. The Perkiomen has often been proposed as a source of water-supply for Philadelphia, and about 11½ miles above its mouth there is said to be an excellent site for a reservoir, where a dam 65 feet high would back up over 6 miles and flood over 15,000 acres. The stream drains principally a trap and sandstone district, and nearly one-third of the entire drainage area is wooded, and likely to continue so.

Valley creek, which enters from the south 4 miles below Phœnixville, is a smaller stream, but well utilized, though with some sites unimproved. The stream is said to be quite uniform in flow. Pickering creek, French creek, and the other creeks from the south below Reading run small grist-mills with two or three pairs of stones, which can run at full capacity only six or eight months, and are sometimes obliged to stop. French creek, however, affords power for the Phœnix Iron Company at Phœnixville, 50 horse-power in all, with three falls (from one dam) of 12, 14, and 16 feet, respectively.

Manatawny creek, entering at Pottstown from the north, has considerable fall and many mills. At the mouth is a flour-mill with a fall of 12 feet, and 75 horse-power during eight months. There are several forges and rolling-mills above, one at Glasgow, a mile above Pottstown, and one at Pine Iron Works. There are several unimproved powers on this stream, formerly used by forges; one at Spring forge, near Earlville, with a fall of 18 feet or over; the Spang forge, at Spangville, with about 15 feet; Snyder's lower forge, in Rockland township, with 20 feet; Snyder's upper forge, with also about 20 feet; and Lobach forge, near Lobachville, about 20 feet. An abandoned forge is also mentioned between Pine and Glasgow, with a fall of 10 feet or more. These forges are idle on account of lack of fuel and convenient means of transportation, the timber for making charcoal having been for the most part cut down.

Tulpehocken creek, which enters from the west, opposite Reading, is quite a large stream, draining a limestone region, and, with its tributaries, quite extensively utilized. It is followed by the Union canal for almost its entire length. Regarding its power I have no data except what is given in the table of utilized power. The same may be said regarding Maiden creek. On the Little Schuylkill there are a number of small grist-mills in the mountain region, and near its head-waters some powder-mills. The powers are all small. A mile above Port Clinton are Inness' rolling-mills, with a fall of 12.5 feet, and 110 horse-power or more during part of the year, there being no waste in dry weather, and the mill running twenty-two hours.

Generally speaking, it may be said that most of the good sites for power on the tributaries of the Schuylkill are occupied, the utilized power in the basin being very large, as the table on pages 114 to 121 shows.

TRIBUTARIES OF THE DELAWARE BETWEEN THE SCHUYLKILL AND LEHIGH RIVERS.

Proceeding up the Delaware, the most important tributaries from Pennsylvania between the Schuylkill and the Lehigh are the Neshaminy and the Tohickon, small streams like the tributaries of the Schuylkill, quite well utilized, and with no important sites not occupied. The tributaries below Easton from New Jersey, too, are,

a These quotations are from a letter from Mr. E. F. Smith, chief engineer of canals, to whom I am much indebted for valuable information and for all the data in the tables.

with one exception, almost valueless for power, being very variable in flow, and almost dry in the summer. The Musconetcong river, which takes its rise in Morris county, near the sources of the Raritan, and pursues a southwesterly course, forming the boundary line between Warren county on the north and Morris and Hunterdon counties on the south, flows by the towns of Hackettstown and Bloomsbury, and drains an area of about 150 square miles, comprising a narrow limestone valley with a shallow covering of drift. Its source is lake Hopatcong, the largest lake in New Jersey, a beautiful sheet of water on the summit of the Highlands, 914 feet above mean tide,(*a*) and covering an area of about 2,800 acres. Its original area was 1,500 acres, but it was raised 10 feet to enable it to serve as a feeder for the Morris and Essex canal, by which its area was increased by 1,300 acres. Its storage capacity is 8,700,000,000 gallons, and the canal company owns the right to control its flow, with the exception of a small portion owned by a mill near the outlet. The flow of the Musconetcong river is, on account of this lake and some other smaller lakes which are tributary to the stream, very steady, and freshets are never violent. The bed is gravel and rock, and the facilities for the utilization of the power are good. The fall of the stream is very large, its elevation at its mouth being about 126 feet,(*b*) and its length about 45 miles, so that the slope averages 15 feet or more per mile. The rainfall in this region of the state is about 48 inches—12 in spring, 14 in summer, 12 in autumn, and 10 in winter—a distribution in itself favorable for constancy of flow. No data regarding the actual flow, however, could be obtained, except such as may be inferred from the data regarding power. The first mill is at the mouth of the stream, at Riegelsville, where a fall of 22 feet is used, with a race three-quarters of a mile long and a dam 6 feet high, to drive a paper- and grist-mill, using in all about 150 horse-power, which, however, can be obtained during only about seven months, being about 100 to 120 horse-power during the rest of the time. At Finesville, a few miles above, there is a forge and knife factory, using a fall of 8.5 feet, and 65 horse-power all the year, with always a waste. At Hughesville, the paper-mill of the Warren Manufacturing Company uses a fall of 28 feet, with a dam 20 feet high, and 250 horse-power during four months. The paper-mills are run night and day, and steam is used when the water is low. At Bloomsbury several mills are run from one dam, with a fall of 9 feet, and above are a number of small mills of various kinds. The stream is no doubt the best water-power stream emptying into the Delaware from New Jersey. There are said to be no sites not occupied, except one below Penville, and 20 feet just above the dam of the Warren Manufacturing Company. If, however, the elevations given above are correct, there must be a large unimproved fall, although there may be no good locations not occupied.

The next tributary of the Delaware which it is necessary to describe is

THE LEHIGH RIVER.

This stream, one of the most important affluents of the Delaware, rises in Wayne and Lackawanna counties, Pennsylvania, and pursues a roundabout course, first in a southwesterly direction, then south, southeast, and finally east, emptying into the Delaware at Easton. It forms first the boundary line between Lackawanna and Luzerne counties on the north, and Monroe and Carbon on the south, then flows through the latter county and becomes the boundary between Lehigh and Northampton counties, finally flowing through parts of both of them before reaching its mouth. Its length, measured along the stream, is not far from 100 miles, while in a straight line it is only about 45 miles from source to mouth. The stream drains a total area of about 1,330 square miles, and in its course it passes a number of cities and towns, among which may be mentioned Easton, Glendon, Bethlehem, Allentown, Hockendauqua, Catasauqua, Slatington, Parryville, Lehighton, and Mauch Chunk. It is controlled by the Lehigh Coal and Navigation Company, and by means of locks, dams, and canals has been made navigable as far as Stoddartsville, although that part above Mauch Chunk has been abandoned for a number of years. The fall of the stream is shown by the following table:

Declivity of the Lehigh river. (*c*)

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	159			
			12	46	3.8
Bethlehem	12	205			
			21	145	6.9
Slatington	33	350			
			9	100	11.1
Lehighton	42	450			
			4	54	13.5
Mauch Chunk, below dam	46	504			
			8	186	23.2
Eight miles above Mauch Chunk	54	690			
			16	415	25.9
Near White Haven	70	1,105			
			13±	352	27.1
Stoddartsville	83±	1,457			

a Cook's *Geology of New Jersey*, 1868, page 27.

b Cook's *Report of the Geological Survey of New Jersey*, 1880, page 76.

c For all but the last of these elevations I have to thank Robert H. Sayre, esq., superintendent and engineer of the Lehigh Valley Railroad Company.

It will be seen that the stream has a very large fall. Descending rapidly from the high plateau where it takes its rise, it falls at the rate of over 10 feet per mile until within 15 or 20 miles of its mouth, when it reaches the rolling farming country of Lehigh and Northampton counties, where its slope is reduced to 4 or 5 feet per mile.

Regarding the flow of the stream I could obtain no data. It is very variable, and the freshets are quite sudden and violent. The water has risen to a height of 11 feet on the dam (280 feet long) at Mauch Chunk. There are no lakes in the basin except a few very small ones on some of the upper tributaries, of no value as regulators of flow. Neither are there any artificial reservoirs except mill-ponds and the ponds of the navigation dams, but these afford little storage, and serve no purpose as regulators. The facilities for artificial reservoirs may be called good, I think, and storage reservoirs could probably be built on many of the tributaries; though on the main stream the fall is too great. The rainfall over the basin is about 43 inches—11 in spring, 14 in summer, 10 in autumn, and 8 in winter. This distribution is about the same as on the valley of the Schuylkill, but on account of the topography and the absence of reservoirs I believe the flow of the Lehigh will be found to be the more variable. The bed of the stream is rock for almost the entire distance, sometimes overlaid with a thin layer of drift, but often at the surface. The banks, especially in the upper part, are rocky and high, and the facilities for dams are of the very best. In some places, in fact, especially between Mauch Chunk and White Haven, the banks are so high and bold that the valley of the stream is simply a gorge, and there is no place for mills or villages.

There is very little power used from the Lehigh except what is taken from the canal or the canal dams on lease from the canal company. As in the case of the Schuylkill, the company controls the flow of the stream, so that mills using power directly from the stream are liable to be short of water at times. The canal company, however, leases a considerable quantity of water for power, as the table below shows. Water is leased by the square inch under a head of 3 feet, measured to the center of the orifice, the price paid varying from $1 to $4 per square inch, according to the fall, and according as the water is discharged into the river or into a lower level of the canal. The water used by mills is never gauged in any other way than by putting in an orifice of a certain size. Some mills, which discharge into lower levels of the canal, have the right to all the surplus or feed water, but the table shows that most of the mills discharge into the river. The mills can generally run at full capacity nearly all the year. There is traffic on the canal only from April 1 to December 15, and during the rest of the year water is let around the locks to supply the mills. The water is drawn off from the canal for from two to four days each year for cleaning and repairs, and except in times of extreme low water there is always enough water to supply the mills. In case of interruption of the supply on account of low water, extended repairs, etc., no abatement in the price is allowed to mills unless the interruption is for thirty days or over; but this very rarely occurs.

As regards power available, it is stated that a large quantity can still be supplied by the company, and that there are numerous points along the river, on the canal, or at the dams where power could be leased by the company.

The following tables give the statistics of power and dams:

Water-power used from the canal of the Lehigh Coal and Navigation Company.

No.	Name and kind of mill.	Location.	Number of square inches.	Head and fall.	Discharge to river or canal.	Approximate quantity of water per second.	Approximate horse-power, gross.
				Feet.		*Cubic feet.*	
1	Stewart's wire- and rolling-mills	South Easton	1,545	21	River	94	225
2	Maxwell & Palmer's grist-mill	...do	100	21	...do	6	15
3	McKean & Co.'s cotton-mill	...do	258	21	...do	16	38
4	McKean & Co.'s weaving-mill	...do	587	21	...do	35	84
5	Furnace and machine-shop	...do	1,180	21	...do	72	172
6	Glendon iron-works	Glendon	1,600	21	...do	98	233
7	Cement-mill (*a*)	Whitehall	500	8	Canal	30	27
8	Foundery and machine-shop (*a*)	Bethlehem	140	8	...do	8	8
9	Barrel factory	...do	300	12	River	18	25
10	Grist-mill	Allentown	450	12	...do	27	37
11	Grist-mill	Lower Catasauqua	450	12	...do	27	37
12	Furnace and rolling-mill	Catasauqua	1,000	8	Canal	60	55
13	Grist-mill	Lowry's	450	13	River	27	40
14	Slate factory	Treichler's	180	13	...do	10	16
15	Grist-mill	...do	300	13	...do	18	27
16	Grist-mill (*b*)	Frenchtown	450	8	Canal	27	25
17	Paint-mill	Bowman's	300	15	River	18	31
18	Paint-mill (*a*)	...do	400	15	Canal	24	41
19	Grist-mill (*c*)	Laubach's	550	6	River	33	22

a Only feed-water. *b* Only eight months by water. *c* Water procured since 1881.

Dams on the Lehigh river belonging to the Lehigh Coal and Navigation Company.

No.	Locality.	Height of fall.	Length.	Approximate length of pool.	Approximate width of pool.	Approximate area of pool.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*
1	Easton	16	340	10,000	400	92
2	Glendon	12	700	15,500	800	289
3	Allentown	10	500	6,000	500	69
4	Hockendauqua	0	550	5,200	400	48
5	Lowry's	13	450	10,000	400	92
6	Above Treichler's	14	480	15,500	500	178
7	Lehigh gap	6	500	5,200	500	60
8	Parryville	12	480	4,000	500	46
9	Mauch Chunk	12	280	4,000	300	27
10	Above Mauch Chunk (*a*)	19	380	5,200	400	48
11	Hickory run (*a*)	28	190	10,000	400	92
12	Tannery (*a*)	30	306	5,200	400	48
13	Bridgeport (*a*)	22	293	4,000	450	41
14	White Haven (*a*)	23	375	4,000	450	41

a Abandoned.

These dams are all substantial structures of crib-work filled in with stone. They are generally 60 feet wide up and down stream, on rock foundation, and to build them now would cost from $20,000 to $35,000 apiece. Those above Mauch Chunk are built with a partly-sloping face. The canal is 60 feet wide at top, 40 feet at bottom, and 6 feet deep.

Below Mauch Chunk there are only a few small mills using power directly from the river, with wing-dams. Details regarding them are unnecessary. Above Mauch Chunk the navigation works have been abandoned, but the dams are still in existence and in quite good condition. Between Mauch Chunk and White Haven the river flows through a narrow gorge, closely followed by the Lehigh Valley and the New Jersey Central railroads; and although the fall is very large, and the theoretical power also, but little is practically available, on account of the contracted situation and the lack of building-room. There are a few places, however, where dams might be located and power obtained, and at the already existing dams belonging to the company a considerably greater amount of power could be used than is used at present. Packer's dam, the first above Mauch Chunk, is entirely unemployed; and the same is true of Hickory Run dam. The Tannery dam is used by one saw-mill, the Bridgeport dam by a saw-mill, and the White Haven dam by two saw-mills and a foundery. All the mills below White Haven, as well as those below Mauch Chunk, pay rent to the company for their power. Above White Haven, although the stream offers considerable available power, there are only a few small saw-mills and a tannery.

THE TRIBUTARIES OF THE LEHIGH RIVER.

The table on page 113 gives the drainage areas of the principal tributaries of the Lehigh. They are all small streams, and I learned of no peculiarities regarding their power. They have a large fall, a gradual descent, and are utilized to a considerable extent. Their flow is variable, but not more nor less than that of other streams in eastern Pennsylvania. The valley of the Lehigh is the seat of considerable manufacturing, the principal industry being that of iron-working, but considerable steam-power is used in preference to water-power.

The tributaries above White Haven are utilized only by saw-mills and tanneries. Bear creek, which enters 8 miles above that place, is said to have a very rapid fall and some cataracts; but it is now utilized only for driving logs. Tobyhanna creek is a similar stream with several falls. On several of the small streams in this vicinity there are "splash-dams", such as have been noticed on the West branch of the Susquehanna, but none of the ponds are very extensive. The tributaries between White Haven and Mauch Chunk are small streams, little utilized, but with large falls. The powers are small and the facilities for building are often poor. In view of the cheapness of steam-power in this coal-producing region, and its convenience, they will scarcely be soon utilized.

The tributaries below Mauch Chunk are more important and better utilized, although on all of them there are numerous sites not occupied. The most important of these streams is the Little Lehigh, which enters at Allentown. It drains a limestone region, and its flow is said to be quite constant. Its basin is hilly, its banks high, and on the stream and its tributaries there are grist-mills, as well as mills of other kinds. It is an excellent stream for power, and, although the best sites are probably occupied, there are numerous others which could be developed. The grist-mills have generally 2 to 4 pairs of stones and run at full capacity during eight or nine months. The city of Allentown pumps its water-supply, which is obtained from a spring, by means of water-power obtained from the Little Lehigh, with a fall of 6 or 8 feet. Monocacy creek, which enters the Lehigh at Bethlehem, is a similar stream, but not so constant. It runs a number of grist-mills.

Ascending the Delaware from the mouth of the Lehigh, the first stream we meet is Bushkill creek, emptying less than a mile above the Lehigh. It is a small stream rising in Northampton county, but it descends from the Blue mountains with a very rapid fall over a rocky bed, and is in all respects an excellent stream for power. It is utilized extensively for grist- and paint-mills, all the best sites being occupied. Martin's creek is another small stream from Northampton county, somewhat similar in character. At its mouth is a cotton-mill, not now running, with a fall of 28 feet. Its flow, however, is said to be very variable.

The most important of the tributaries from New Jersey, above Easton, is the Pequest creek, which rises in Sussex county, New Jersey, and pursues a southwesterly course through Sussex and Warren, emptying into the Delaware at Belvidere, after draining an area of about 160 square miles, according to my measurements. Its length is about 30 miles along its general course, and its drainage basin, lying in the highlands of New Jersey, comprises a hilly country, quite well wooded. The stream is fed by a number of small lakes and ponds, the principal of which are Green's, Glover's, Rice, Alamuche, Panther, Long, and Sickles' ponds. They are all small sheets of water, but by their number may make up for their small size, and may serve to regulate the flow to a considerable extent. Until a few years ago the stream, like the Passaic above Little Falls, was bordered by swamp-lands from Danville, in Warren county, up to the Sussex line and beyond, a distance of over 6 miles in a straight line; and although the fall of the stream within this distance was considerable, its course was so tortuous and so obstructed by fallen timber that its slope was very small. Within a few years these lands, known as the Great meadows, and covering 5,500 acres or more, have been drained, with much benefit to the health and agriculture of the region. The fall of the stream probably averages, from source to mouth, about 8 or 10 feet per mile, or more. Regarding its flow, or that of any of the tributaries from New Jersey, no data are at hand. It may be estimated by comparing the tables on pages 9 and 10. The bed of the stream is sometimes rock, but more often drift, which covers the valley in some places to a considerable depth. The power of the stream is utilized to run a number of small grist- and saw-mills, the most important power being at the mouth, where, within a distance of a mile, there is a very considerable fall. The first power is a saw-mill with about 12 horse-power, and a flour-mill with about 95 horse-power, both from the same dam, the falls being 14 and 16 feet, respectively. Just above is a second dam, supplying two flour-mills, with together 50 horse-power, the fall being 6 or 7 feet. Half a mile above is a third dam, supplying three mills, viz, a flour-mill with 30 horse-power, a wheel and wagon factory with about 40 horse-power, and a furniture factory with 60 horse-power, the fall being 18 feet at all the mills. Full capacity can not be obtained all the year. The dams were built over 40 years ago. Above Belvidere there are no powers worth describing. The fall of the stream is not all utilized, but with the exception of a fall of 13 feet just above Belvidere, which is said to be unimproved, no other sites were brought to my notice.

Similar to the Pequest are the other tributaries of the Delaware from New Jersey. An important feature of this region is the presence of a large number of small ponds, as in the valley of the Pequest, by which the flow of the streams is rendered much more constant than it otherwise would be, and the freshets much less destructive and violent. The facilities for the construction of artificial reservoirs are also very good; and if it were desired to utilize these streams extensively, their flow could be regulated to a considerable extent. These streams, however, are not very easy of access, at least those above the water-gap, there being no railroad along the Delaware between that point and Port Jervis. I have no details regarding their power, but the only mills they run are grist- and saw-mills, the former with two or three pairs of stones, which they can run only part of the time. The principal of these streams are Paulin's kill and Flat brook, which drain valleys nearly parallel with the Delaware. On the former, which drains a long anticlinal limestone valley, there are a number of ponds, several of them covering nearly a square mile each. Its utilized power is insignificant, but its fall is probably not much less than that of the Pequest. It is bordered at one place, near Newton, by swamps covering over 1,800 acres.

The tributaries of the Delaware from the west, between the water-gap and Port Jervis, have generally a very rapid fall, descending from the same elevated plateau which gives rise to the Lehigh, and flowing nearly south or southeast, through deep and narrow channels, in which occur innumerable cascades. They seem to be excellent streams for power, by reason of the great fall and of the numerous lakes which are tributary to them, their chief disadvantage being their inaccessibility. Being small streams, they afford, of course, no very remarkable powers. They are utilized, like the New Jersey tributaries, by saw- and grist-mills, running generally only for part of the year, although the flow of the streams is not remarkably variable. The first and largest of these streams, above the water-gap, is the Analomink (or Brodhead's) creek, which drains an area of nearly 300 square miles, taking its rise in Pike county, very near the border of Monroe, and flowing nearly south, past the town of Stroudsburg, emptying into the Delaware just above the water-gap. It has only a few small lakes tributary to it, and its flow is therefore probably more variable than that of the streams north of it; but being followed for some distance by the Delaware and Lackawanna railroad, it is more accessible than any of the others. Its bed is rocky, and the facilities for power seem to be of the best. It is utilized only by a few small grist- and saw-mills, a foundery, etc., and there are numerous sites not occupied; in fact, only a small part of the available power of the stream is yet turned to account. The stream has several tributaries which also afford good power. Marshall's creek, which joins it just above its mouth, has a large fall but a very variable flow. A few miles from Stroudsburg it has a fine

cascade. Pocono creek, which flows through Stroudsburg, just below which place it joins the main stream, runs, with its tributaries, a number of mills, including at Stroudsburg a grist-mill, a saw-mill, and a woolen-mill, all from one dam, using a fall of about 14 feet, and together about 125 or 150 horse-power, which, however can be obtained during only about six months.

Bushkill creek, which enters the Delaware at Bushkill, is similar to the Analomink, but is fed by five or six lakes of small size. Five miles from its mouth there is a fall of 30 feet. On Raymond's kill, near Milford, there is a cataract, and on the Saw kill, which flows through the town, there is a beautiful cascade a mile above the town, the stream falling over a hundred feet into a winding chasm.

The tributaries of the Delaware above the northern boundary of New Jersey, both those from New York and those from Pennsylvania, partake of the general character of those just described. In both states there are innumerable lakes and ponds scattered over their drainage basins, and their fall is generally quite large, though as the Delaware is ascended the fall of the tributaries becomes probably less. Regarding their power, details could be obtained in only a few instances. From what I could learn, I should judge the power to be in all respects excellent, and the reason why they are not utilized to a greater extent is that they are generally not very accessible, and that the region is sparsely settled and not much developed. With the exception of a few mills on the tributaries of the Lackawaxen, there is no manufacturing on any of these streams. The lumber interest has always been the most important one, and the mills are generally saw-mills; but, as the timber is being cut down, these are gradually being abandoned.

Considering, first, the tributaries from New York, the Neversink is the first of importance. Taking its rise in the western part of Ulster county, it pursues a nearly southerly course, entering the Delaware about a mile below Port Jervis, and draining a narrow valley measuring nearly 350 square miles, comprising a wild and broken country, very little developed. Its fall is large, its bed very rocky, and its flow very variable, the freshets being, it is said, very severe, although it is fed by 15 or 20 small ponds. Its power is almost all unimproved, there being only a few small saw-mills and tanneries in operation. Its tributaries, however, are better utilized.

The next important tributary of the Delaware is the Mongaup, a small stream draining only about 230 square miles, rising in Sullivan county, through which it flows in a direction nearly due south, entering the Delaware at Mongaup after forming the boundary between Orange and Sullivan counties. It is fed by over twenty lakes and ponds, some of which are of considerable size, so that its flow is probably more regular than that of the Neversink, although no accurate data regarding this point are at hand. Its basin is characterized as a wilderness, and although its fall is rapid and its available power very large, it is utilized only to a very small extent. In former times it was quite well utilized by saw-mills, tanneries, etc., but the lumber and bark have become scarce, and many of the mills have been abandoned. It offers numerous sites for power, and is said to have some very large falls. Six miles from the mouth is a fall known as Little falls, and 4 miles above are Big falls, formerly utilized by a saw-mill. Its bed is very rocky and the facilities for dams are excellent. As in the case of many of these streams, however, the valley is narrow, and not much storage can be obtained. It is on the smaller tributary streams that the lakes and ponds are generally situated. The upper part of the stream is said to be better utilized than the lower, but it is not very accessible. Monticello is probably the nearest railroad point.

Passing a number of small streams, we come to the Callicoon, a stream similar to the Mongaup. It formerly was the seat of an immense lumber business, but is now little used. It is fed by a number of lakes, and it may be mentioned that many of the lakes in the vicinity have been raised by dams at their outlets, affording good constant power to small mills.

The East branch of the Delaware will be described after the remaining tributaries of the main stream from Pennsylvania have been considered. The first of these above Port Jervis is Shohola creek, a stream similar to those just described, but regarding whose power I have no data. The next important one, and the largest affluent the river receives in this part of its course, is the Lackawaxen river. It is formed by the union of two branches, both of which rise, not far apart, in the northern part of Wayne county, and flow nearly south, uniting at Honesdale, from which point the river flows southeast, and then east, passing into Pike county, and joining the Delaware at Lackawaxen. The drainage area measures about 600 square miles, and comprises a hilly and broken country, forming part of the high plateau which contains the sources of the Lehigh and the Lackawanna. The basin is dotted with numerous lakes and ponds, of which thirty or more may be counted on the map, and the facilities for storage are excellent. The stream is followed from its mouth as far as Honesdale by the Honesdale branch of the Erie railroad, and also by the Delaware and Hudson canal, and the canal company has already constructed, as feeders for the canal, ten large reservoirs on the tributaries of the West branch, and one on the East branch, above Honesdale, statistics regarding which are given in the following table:

Reservoirs of the Delaware and Hudson Canal Company on the tributaries of the Lackawaxen.

No.	Name.	Height of dam.	AREA.				Capacity.
			High water.		Low water.		
		Feet.	*Square feet.*	*Acres.*	*Square feet.*	*Acres.*	*Cubic feet.*
1	Stanton pond	19	11,625,000	266.87	2,392,500	54.92	135,643,750
2	Keen's pond	18.5	4,682,500	107.49	1,452,500	33.34	61,145,000
3	Elk pond	14	7,972,500	183.02	5,432,500	124.71	92,707,500
4	White Oak pond	26	15,577,500	367.61	2,585,000	59.34	248,788,750
5	Swamp pond	20	2,417,500	55.49	732,500	16.81	33,657,500
6	Long pond	20	6,685,000	153.41	2,782,500	63.87	93,783,750
7	Stevenson's pond	22	4,305,000	98.82	1,085,000	24.90	69,407,500
8	Miller's pond	24.5	4,230,000	97.10	527,500	12.11	73,834,750
9	Beaver Meadow pond	25	9,347,500	214.58	1,100,000	25.25	137,995,750
10	Lower Woods pond	18.5	4,177,000	95.56	1,810,000	41.55	61,758,750
11	Cajaw pond	14	4,055,000	93.09	1,175,000	26.98	36,412,500

NOTE.—All but No. 10 are on the West branch; No. 10 is on the East branch.

These reservoirs, aggregating a capacity of over 1,045,000,000 cubic feet, are emptied during the summer for the supply of the canal, which is fed by means of dams across the stream, there being one at Honesdale and three between Honesdale and Lackawaxen, besides the one across the Delaware at the latter place. Their effect is, of course, favorable on the water-power of the mills above Honesdale.

The stream has a rapid fall, its elevation at Honesdale, 24 miles from the mouth, being about 965 feet, while that of the Delaware at Lackawaxen is about 600 feet, so that the fall of the Lackawaxen below Honesdale is at the rate of 15 feet per mile, while above Honesdale it is probably greater. These figures will serve to give some idea of the fall of the tributaries to the Delaware above the water-gap, for they are all rapid streams, similar to the Lackawaxen.

Regarding the flow of the stream no data are at hand. The rainfall over the basin and all the adjacent territory is about 42 inches—11 in spring, 13 in summer, 10 in autumn, and 8 in winter.

On account of the fact that the main stream below Honesdale is controlled by the canal company, which has the right to use all the water for the canal, if necessary, and also that in dry weather almost all the flow is in fact so used, the water-power of the stream is of little importance, there being, according to the census statistics, only one small mill below the junction of the two branches. Although there is no power used from the canal in this part of its course, it is said that some power could be used at the locks by using the flume-water which flows around through the waste-sluices; but it is probable that the amount of power which could be so used is small, and that none would be available at times. But although the main stream offers no power, its tributaries afford a large amount. The first one which we meet as we ascend the creek is Blooming Grove creek, flowing nearly north from Pike county. It is a small stream, but has a rapid fall and is fed by several lakes. At its mouth a saw-mill and furniture factory use a fall of 15 feet, and within a distance of a little over a mile above there is said to be a fall of over 100 feet not utilized, but which could be easily developed. The stream is said to be very constant in flow.

The next tributary of the Lackawaxen is Paupack creek, a much larger stream than the Blooming Grove, taking its rise in the very corner of Wayne, Pike, and Monroe counties, near the sources of the Lehigh, and flowing nearly north, forming the boundary between Wayne and Pike. It joins the Lackawaxen at Hawley, and drains a total area of about 233 square miles, its length along its general course being about 25 miles. Like the Blooming Grove, it is fed by a number of small ponds, but its flow is probably more variable than that of the latter stream. Rising in the southern part of the high plateau of Pike county, the stream has little power in the upper part of its course, or until within less than 2 miles of its mouth, flowing for a long distance in a bed of gravel and sand, and with only a few small mills. Above the dam at Wilsonville, less than 2 miles from the mouth, there is said to be a number of miles of slack-water, the next power being at Ledgedale, 14 miles above, and the fall between the two points being very small. There is one dam, used only for running logs, within this distance, and the stream often overflows its banks, spreading out from its natural width of about 75 feet to many hundred. Above Ledgedale the fall of the stream is greater, and there are numerous sites for power. On the East branch of the stream there is said to be one fall of 90 feet just below the outlet of a small lake; but all the powers above Wilsonville are unimportant. At that place three saw-mills and a grist-mill are run from one dam, the fall being 22 feet. The dam is a zigzag dam, about 6 feet high, the height being varied 3 feet by means of flash-boards. The natural fall is about 25 feet, so that it is not all utilized. From this point to the mouth, a distance of about 1½ mile, the stream falls very rapidly, its bed being solid rock. It is, in fact, a continuous cataract, and the total fall is said to be over 300 feet. Of this fall only a portion, at Hawley, is utilized. The first mill below Wilsonville is a carriage factory and planing-mill, with a dam about 2 feet high, composed of timbers bolted to the rock, with a fall of 25 feet and a race 250 feet long. The power used is only about 25 horse-power, according to the census statistics of manufactures. Just below the mill a large silk factory has just been built by Mr. C. Lambert, of Paterson, New Jersey, to use

several hundred horse-power, with a fall of 56 feet. The dam, which was built in June, 1880, at a cost of $1,000, is 125 feet long and 8 feet high, built of timber and stone. A few hundred feet below is a third dam, about 2 feet high, from which lead two races, one on each side, one running a tannery with a fall of 32 feet (over 40 being available), and the other a spoke factory with a fall of 16 feet, and a grist-mill with 20 feet, the power used being small.

The power offered by the Paupack river below Wilsonville is probably the finest in the valley of the Lackawaxen, and perhaps as good as any in the whole valley of the upper Delaware. No gaugings of the stream are on record, except some observations made while the dam was being built, according to which the discharge was 125 cubic feet per second. It is probable, however, that the flow is at times much smaller than this, and I should estimate the minimum at not over 50 cubic feet per second and the flow during the low season of ordinary years as perhaps 75 cubic feet per second. This would afford 8.5 horse-power per foot fall, and with the large fall available the power which could be developed is quite large. It could no doubt be very much increased by artificial storage.

Middle creek, which joins the Lackawaxen at Hawley, is a small stream, but has considerable available power. No details are at hand.

The West or main branch of the Lackawaxen affords considerable power. At Honesdale there are three dams, the lower one, 9 or 10 feet high, supplying a planing-mill, the next being the canal feeder-dam, and the next running a grist-mill, with a fall of 7 feet. At Seelyville, a mile above, there is quite an important power. There are two dams, about 300 feet apart, the upper one 16 or 18 feet high, built of stone in hydraulic cement, and the lower one, 2 feet high, of timber. The upper dam runs a stick factory with a fall of 16 feet, and a saw-mill and woolen-mill with a fall of 28 or 30 feet, discharging below the lower dam. The lower dam, below which is a natural fall of 12 or 14 feet, runs a machine-shop and sash-and-blind factory with a fall of 14 feet. The total power used can not be stated with accuracy. There are other smaller establishments of various kinds on the stream above this point.

The East branch of the Lackawaxen, known as the Dyberry, has a fall of 30 feet at Tanner's falls, 7 miles above Honesdale, used by a tannery and some saw-mills; but no further details regarding the power of the stream are at hand.

The other tributaries of the Delaware below the junction of the two branches are utilized by small saw-mills, but their power, although considerable, does not merit a special description, as they closely resemble the tributaries already considered.

It remains to describe the two branches of the Delaware which unite at Hancock. The East branch, or Pepacton, takes its rise in the eastern part of Delaware county, through which it flows in a southwesterly direction for a distance of about 50 miles in a straight line. It drains an area of about 919 square miles, comprising a region as yet but little developed, passing no large towns, and with few mills except small grist- and saw-mills. Its fall is considerable, but gradual, there being no cataracts or even remarkable rapids, so far as I could learn. Its bed is mostly gravel and sand, and its flow subject to large variations. There are a few lakes in the basin, but they are small in comparison with the size of the stream, and do little to regulate its flow; though the facilities for artificial storage are said to be good. The drainage basin is quite well wooded, and is the seat of considerable lumbering. Formerly many rafts were sent down the East branch, but now the lumbering is more confined to the Pepacton. Details regarding the power of the stream could not be obtained with the time at disposal. That which is utilized is tabulated below, and in regard to that which is available, it may safely be said that it is very large, though no specially good sites can be indicated.

Of the tributaries of the Pepacton many have been utilized to a considerable extent to run saw-mills, but a large proportion of these mills have been abandoned in late years on account of the want of timber, so that the streams are now utilized only to a very small extent. The principal of these streams is the Beaver kill, which rises in the western part of Ulster county, near the sources of the Neversink, and flows nearly west, draining about 320 square miles. Its fall is large, but probably not so large as that of the Mongaup and the Neversink, its neighbors. It offers an abundance of fine power, but little of which is utilized, for saw-mills and tanneries. Trout brook, one of its affluents, takes its rise in a lake known as Long pond, about 2 miles long by three-eighths of a mile wide. The level of this lake is raised 6 feet by a dam, and just below the outlet is a natural fall of 25 feet, utilized by a saw-mill, and there are other saw-mills lower down. There are other lakes in the vicinity whose outlets are dammed and the fall utilized for power.

The West or main branch of the Delaware is similar in general character to the East branch, but it drains a more open, cultivated, and better-developed country. Its basin is not so well wooded, and it is fed by but a few small lakes, so that, as would be expected, its flow is said to be more variable than that of the East branch. Its fall is gradual and its utilized power very small. Less than a mile above the forks is a saw-mill with a fall of 7 feet; at Hale's eddy there is a second one with a fall of 5 feet; at Deposit is a third with a fall of 6 feet. At Stiles' settlement, a mile and a half above, a fall of 5 feet supplies power to several mills of different kinds, and above are other small mills. At Delhi a woolen-mill uses a fall of 10 feet, but, with the exception of this and a few other small woolen-mills, the mills are grist- and saw-mills. The available power is doubtless large, but as the slope is gradual I learned of no particular sites.

The tributaries of the West branch do not require detailed description, as none of them are large or important. They have considerable fall, though not so much by any means as the tributaries between Port Jervis and Hancock, and they are sometimes fed by small lakes, which serve to regulate the flow, some of which are dammed. Like the other streams in the vicinity, they are not utilized now as much as they were formerly, on account of the thinning out of the timber.

The following tables have already been referred to. They contain what additional information is needed to give an idea of the power of the Delaware:

Table of drainage areas of the Delaware river and tributaries.

Name of stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Delaware river	Delaware bay	Below junction of East and West branches	1,604
Do	do	Long eddy	1,733
Do	do	Pond eddy	2,946
Do	do	Port Jervis	3,252
Do	do	Below mouth of Neversink	3,600
Do	do	Belvidere (without Pequest creek)	4,550
Do	do	Wycott	4,790
Do	do	Easton (without Lehigh river)	4,880
Do	do	Bull's falls	6,750
Do	do	Lambertville	6,820
Do	do	Scudder's falls	6,894
Do	do	Trenton (without Assanpink creek)	6,916
Do	do	Philadelphia (without Schuylkill river)	8,186
Do	do	Philadelphia (including Schuylkill river)	10,100
West branch	Delaware river	Walton	348
Do	do	Deposit (without Oquaga creek)	519
Do	do	Hale's eddy	634
Do	do	Mouth	685
East branch	do	Above mouth of Beaver kill	520
Do	do	Mouth	919
Little Delaware creek	West branch	do	53
Oquaga creek	do	do	82
Beaver kill	East branch	do	322
Callicoon creek	Delaware river	do	123
Mongaup creek	do	do	231
Neversink river	do	do	346
Basha's kill	Neversink river	do	67
Lackawaxen river	Delaware river	Honesdale	161
Do	do	Mouth	597
Paupack creek	Lackawaxen river	do	233
Blooming Grove creek	do	do	29
Shohola creek	Delaware river	do	91
Bushkill creek	do	do	158
Analomink creek	do	do	289
Bushkill creek (Easton)	do	do	75
Lehigh river	do	Gouldsborough	75
Do	do	White Haven	290
Do	do	Tannery	300
Do	do	Mauch Chunk	581
Do	do	Perryville	727
Do	do	Lehigh gap	870
Do	do	Lowry's	940
Do	do	Hokendoqua	985
Do	do	Allentown (without Little Lehigh)	1,009
Do	do	Glendon	1,328
Do	do	Mouth	1,332
Tobyhanna creek	Lehigh river	do	121
Bear creek	do	do	50
Little Lehigh creek	do	do	177
Schuylkill river	Delaware river	Schuylkill Haven	134
Do	do	Above mouth of Little Schuylkill	200
Do	do	Reading	889
Do	do	Limerick dam	1,142
Do	do	Phœnixville	1,323
Do	do	Pawling	1,707
Do	do	Norristown	1,752
Do	do	Conshohocken	1,787
Do	do	Manayunk	1,817
Do	do	Fairmount	1,880
Do	do	Mouth	1,912

Table of drainage areas of the Delaware river and tributaries—Continued.

Name of stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Little Schuylkill river	Schuylkill river	Mouth	134
Tulpehocken creek	do	do	219
Maiden creek	do	do	205
Manatawny creek	do	do	97
Perkiomen creek	do	do	345
Flat brook	Delaware river	do	58
Little Flat brook	Flat brook	do	14
Pequest creek	Delaware river	Vienna	89
Do	do	Townsbury	94
Do	do	Butzville	118
Do	do	Mouth	161
Musconetcong creek	do	Asbury	122
Do	do	Bloomsbury	138
Do	do	Mouth	150
Paulin's kill	do	do	*a* 170
Pohatcong creek	do	do	*a* 50
Assanpink creek	do	do	*a* 105
Crosswick's creek	do	do	*a* 115
Rancocas creek	do	do	346
Rancocas creek, South branch	Rancocas creek	do	142
Rancocas creek, North branch	do	Pemberton	136
Do	do	Smithville	154
Do	do	Mouth	*a* 164
Cooper's creek	Delaware river	do	*a* 55
Big Timber creek	do	do	*a* 56
Mantua creek	do	do	*a* 51
Raccoon creek	do	do	*a* 53
Oldman's creek	do	do	*a* 43
Salem creek	do	do	*a* 109
Alloway's creek	do	do	*a* 285
Cohansey creek	Delaware bay	do	*a* 100
Do	do	Bridgeton	52
Maurice river	do	Millville	217
Do	do	Mouth	380
Christiana creek	do	do	465
Do	do	Above mouth of White Clay creek	46
White Clay creek	Christiana creek	Mouth	98
Red Clay creek	White Clay creek	do	52
Brandywine creek	Christiana creek	Coatesville	25
Do	do	Wilmington	238

a These figures are taken from Professor Cook's report on the *Geology of New Jersey*. My own measurements did not agree with his very well, giving the areas always considerably larger, generally by from 10 to 20 per cent. Thus, Professor Cook gives the following as the drainage areas of some of the streams named above, and for which the above table gives my results: Pequest, 140; Musconetcong, 124; Rancocas, 329; Maurice, 360.

Table of utilized power on the Delaware river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Delaware river	Delaware bay	Pennsylvania	Bucks	Flouring and grist	(?)6	35	263
Do	do	do	do	Flouring and grist	1	*a* 10½	8
Do	do	do	do	Paper (*b*)	1	9	165
Do	do	New Jersey	Mercer	Wood-turning (*c*)	1	7	25
Do	do	do	do	Machinery (*c*)	2	25	40
Do	do	do	do	Planing (*c*)	2	28	85
Do	do	do	do	Hardware (*c*)	1	16	20
Do	do	do	do	Plaster (*c*)	1	14	97
Do	do	do	do	Carpentering (*c*)	1	18	12
Do	do	do	do	Flouring and grist (*c*)	5	78	170
Do	do	do	do	Rolling-mill (*c*)	1	11	100
Do	do	do	do	Woolen (*c*)	4	52	100
Do	do	do	do	Flouring and grist	4	*d* 91	130
Do	do	do	Hunterdon	Cotton (*e*)	1	8½	65

a From Delaware Division canal. *b* Being built. *c* At Trenton. *d* From canal to river. *e* At Lambertville.

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Delaware river	Delaware bay	New Jersey	Hunterdon	Machinery (*a*)	1	19	100
Do	do	do	do	Paper (*a*)	3	35	196
Do	do	do	do	Twine (*a*)	1	9	60
Do	do	do	do	Flouring and grist (*a*)	2	37	95
Do	do	do	do	Saw (*a*)	1	17	25
Do	do	do	do	do	1	2	18
Do	do	do	do	Flouring and grist	1	8	22
Do	do	Pennsylvania	Monroe	do	(?)1	8	16
Do	do	do	Wayne	do	(?)	(?)	(?)
Tributaries of	Delaware bay	Delaware	Sussex	Woolen	1	......	5
Do	do	do	do	Flouring and grist	10	61	157
Do	do	do	do	Saw	12	81	249
Do	do	do	Kent	Woolen	1	8	30
Do	do	do	do	Dye-woods, etc.	1	6	40
Do	do	do	do	Upholstering materials	1	6	18
Do	do	do	do	Foundery	1	8	12
Do	do	do	do	Saw	3	31	60
Do	do	do	do	Flouring and grist	24	210	699
Christiana creek	Delaware river	do	New Castle	Agricultural implements	1	12	15
Do	do	do	do	Flouring and grist	5	76	147
Brandywine creek	Christiana creek	do	do	Gunpowder	......	59	500
Do	do	do	do	Cooperage	1	8	10
Do	do	do	do	Flouring and grist	(?)2	27	155
Do	do	do	do	Paper	3	50	500
Do	do	do	do	Cotton	5	64	470
Do	do	Pennsylvania	Chester	Flouring and grist	16	222	342
Do	do	do	do	Saw	7	101	126
Do	do	do	do	Machinery	1	6	20
Do	do	do	do	Paper	4	34	111
Do	do	do	Delaware	Flouring and grist	1	4	56
Do	do	do	Chester	Iron and steel	2	36	120
Other tributaries of	Delaware river	Delaware	New Castle	Woolen	5	50 ±	189
Do	do	do	do	Rolling	2	30	189
Do	do	do	do	Paper	1	12	84
Do	do	do	do	Carriage materials	1	13	8
Do	do	do	do	Saw	6	90	122
Do	do	do	do	Flouring and grist	25	435	621
Do	do	Pennsylvania	Chester	Fertilizers	1	8	25
Do	do	do	do	Butter and cheese	2	36	10
Do	do	do	do	Flouring and grist	76	1,352	1,183
Do	do	do	do	Saw	24	410	331
Do	do	do	do	Leather	1	14	8
Do	do	do	do	Plaster	1	12	40
Do	do	do	do	Machinery	2	26	29
Do	do	do	do	Paper	13	225	454
Do	do	do	do	Wood-turning	1	21	10
Do	do	do	do	Woolen	9	150	230
Do	do	do	do	Iron	1	12	......
Do	do	do	Delaware	Flouring and grist	27	488	549
Do	do	do	do	Saw	9	159	129
Do	do	do	do	Cutlery, etc.	1	20	40
Do	do	do	do	Paper	6	119	215
Do	do	do	do	Cotton	9	......	816
Do	do	do	do	Woolen	13	187	555
Maurice river	Delaware bay	New Jersey	Gloucester	Flouring and grist	1	7	30
Do	do	do	Cumberland	Water-works	1	24	40
Do	do	do	do	Foundery	1	24	60
Do	do	do	do	Flouring and grist	1	24	40
Do	do	do	do	Cotton	1	24	400
Do	do	do	do	Blacking	1	24	50
Do	do	do	do	Bleachery	1	24	100
Do	do	do	do	Saw	1	11	70
Cohansey creek	do	do	do	Flouring and grist	7	108	141
Do	do	do	do	Saw	2	20	30
Do	do	do	do	Rolling	1	14	150

a At Lambertville.

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Rancocas creek	Delaware river	New Jersey	Burlington	Flouring and grist	6	47	275
Do	...do	...do	...do	Saw	6	53	142
Do	...do	...do	...do	Cotton	1	6	15
Do	...do	...do	...do	Machinery	1	8	100
Other tributaries of	Delaware bay	...do	Cape May	Flouring and grist	3	14	26
Do	...do	...do	Cumberland	...do	10	86	142
Do	...do	...do	...do	Saw	7	68	133
Do	Delaware river	...do	Salem	Flouring and grist	15	185	396
Do	...do	...do	...do	Saw	13	130	242
Do	...do	...do	...do	Wood-turning	1	8	7
Do	...do	...do	Gloucester	Woolen	1	13	40
Do	...do	...do	...do	Flouring and grist	17	261	378
Do	...do	...do	...do	Saw	8	85	107
Do	...do	...do	Camden	Agricultural implements	1	12	25
Do	...do	...do	...do	Flouring and grist	6	70	154
Do	...do	...do	...do	Saw	2	21	75
Do	...do	...do	...do	Paint	1	15	20
Do	...do	...do	Burlington	Flouring and grist	17	170	443
Do	...do	...do	...do	Saw	8	75	140
Do	...do	...do	Mercer	Woolen	1	18	....
Do	...do	...do	...do	Cotton	1	7½	80
Do	...do	...do	...do	Flouring and grist	9	88	265
Do	...do	...do	...do	Saw	2	22	100
Do	...do	...do	...do	Rubber	2	16	115
Do	...do	...do	...do	Plaster	1	8	25
Do	...do	...do	...do	Wood-turning	1	6	20
Do	...do	...do	Ocean	Flouring and grist	2	24	50
Do	...do	...do	...do	Saw	2	15	28
Do	...do	...do	Monmouth	Flouring and grist	10	103	254
Musconetcong creek	...do	...do	Morris	...do	1	10	55
Do	...do	...do	Warren	Woolen	1	7½	15
Do	...do	...do	...do	Flouring and grist	6	....	240
Do	...do	...do	...do	Paper	1	22	145
Do	...do	...do	...do	Agricultural implements	1	6	8
Do	...do	...do	...do	Foundery	1	9	18
Do	...do	...do	Hunterdon	Cutlery	1	8	65
Do	...do	...do	...do	Paper	1	28	250
Do	...do	...do	...do	Saw	2	20	30
Do	...do	...do	...do	Flouring and grist	4	36	150
Do	...do	...do	Sussex	...do	1	....	18
Pequest creek	...do	...do	Warren	...do	8	77	280
Do	...do	...do	...do	Saw	1	14	12
Do	...do	...do	...do	Carriage	1	16	20
Do	...do	...do	...do	Carriage materials	1	16	20
Do	...do	...do	...do	Furniture	1	16	60
Do	...do	...do	Sussex	Flouring and grist	4	51	100
Do	...do	...do	...do	Saw	2	24	44
Other tributaries of	...do	...do	Hunterdon	Woolen	1	24	8
Do	...do	...do	...do	Sashes, doors, and blinds	1	24	20
Do	...do	...do	...do	Wood-turning	1	....	10
Do	...do	...do	...do	Saw	8	176	193
Do	...do	...do	...do	Flouring and grist	16	322	348
Do	...do	...do	Warren	...do	39	723	1,146
Do	...do	...do	...do	Sashes, doors, and blinds	1	9	10
Do	...do	...do	...do	Wheelwrighting	1	12	20
Do	...do	...do	...do	Saw	14	....	286
Do	...do	...do	...do	Agricultural implements	1	20	9
Do	...do	...do	...do	Furniture	1	....	3
Do	...do	...do	Sussex	Flouring and grist	18	305	448
Do	...do	...do	...do	Brooms, etc	1	9	20
Do	...do	...do	...do	Founderies	2	16	16
Do	...do	...do	...do	Saw	5	75	83
Do	...do	...do	...do	Leather	2	20	23
Do	...do	...do	...do	Woolen	1	....	35
Schuylkill river	...do	Pennsylvania	Philadelphia	Water-works	1	12±	700
Do	...do	...do	...do	Cotton	4	84	630
Do	...do	...do	...do	Cotton and woolen	2	40	23

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Schuylkill river	Delaware river	Pennsylvania	Philadelphia	Paper	4	82	525
Do	do	do	do	Flouring	1	19	21
Do	do	do	do	Woolen	1	20	31
Do	do	do	Montgomery	Rolling	1	8	80
Do	do	do	do	Cotton	2	17	242
Do	do	do	do	Flouring	1	9	30
Do	do	do	Chester	Flouring and grist	2	14	55
Do	do	do	do	Rolling	1	9	40
Do	do	do	Berks	Flouring and grist	2	14	56
Do	do	do	Schuylkill	do	2	20	46
Do	do	do	do	Saw	1	16	24
Do	do	do	do	Gunpowder	1	......	20
Tributaries of	Schuylkill river	do	Philadelphia	Paper	1	16	80
Do	do	do	do	Cotton	1	40	12
Do	do	do	Delaware	Flouring and grist	2	37	55
Do	do	do	do	Saw	1	28	35
Do	do	do	Chester	Agricultural implements	2	29	20
Do	do	do	do	Fertilizers	1	8	25
Do	do	do	do	Hardware	1	7	10
Do	do	do	do	Flouring and grist	41	657	700
Do	do	do	do	Saw	14	195	203
Do	do	do	do	Planing	1	28	20
Do	do	do	do	Machinery	1	5	10
Do	do	do	do	Paper	3	68	67
Do	do	do	do	Rolling	2	40	80
Do	do	do	do	Woolen	2	16	30
Perkiomen creek	do	do	Berks	Flouring and grist	8	124	131
Do	do	do	do	Leather	2	18	26
Do	do	do	Montgomery	Oil	3	47	64
Do	do	do	do	Paper	1	15	20
Do	do	do	do	Sashes, doors, and blinds	1	7	12
Do	do	do	do	Leather	1	6	20
Do	do	do	do	Flouring and grist	23	208	647
Do	do	do	do	Saw	3	33	87
Manatawny creek	do	do	Berks	Iron-forging	1	14	75
Do	do	do	do	Flouring and grist	10	99	188
Do	do	do	do	Saw	3	19	43
Do	do	do	do	Paper	1	14	25
Do	do	do	do	Rolling	1	14	110
Do	do	do	Montgomery	Flouring and grist	1	12	75
Do	do	do	do	Rolling	1	13	100
Tulpehocken creek	do	do	Lebanon	Flouring and grist	2	13	50
Do	do	do	Berks	do	12	68	218
Do	do	do	do	Saw	1	7	17
Do	do	do	do	Rolling	1	8	25
Maiden creek	do	do	do	Flouring and grist	7	43	141
Do	do	do	do	Saw	3	19	72
Other tributaries of	do	do	Montgomery	Woolen	4	50	110
Do	do	do	do	Cotton	1	12½	20
Do	do	do	do	Agricultural implements	1	8	6
Do	do	do	do	Brass foundery	1	26	40
Do	do	do	do	Cutlery	1	6	8
Do	do	do	do	Gunpowder	2	23	33
Do	do	do	do	Paper	2	26	40
Do	do	do	do	Shoddy	1	17	30
Do	do	do	do	Wheelwrighting	1	12	10
Do	do	do	do	Leather	2	11	30
Do	do	do	do	Flouring and grist	71	1,019	1,462
Do	do	do	do	Saw	11	126	195
Do	do	do	Bucks	do	1	......	15
Do	do	do	do	Flouring and grist	14	267	240
Do	do	do	Lebanon	Blacksmithing	1	......	5
Do	do	do	do	Flouring and grist	5	85	73
Do	do	do	Lehigh	Agricultural implements	1	18	8
Do	do	do	do	Foundery	1	18	8
Do	do	do	do	Flouring and grist	4	69	55

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Schuylkill river	Pennsylvania	Lehigh	Saw	1	15	20
Do	do	do	do	Woolen	1	8	20
Do	do	do	Berks	Woolen	4	....	87
Do	do	do	do	Rolling	2	47	165
Do	do	do	do	Forges and blomaries	3	25	66
Do	do	do	do	Blast-furnaces	5	95	120
Do	do	do	do	File	2	21	18
Do	do	do	do	Carriage materials	1	13	8
Do	do	do	do	Agricultural implements	2	19	15
Do	do	do	do	Founderies	3	37	72
Do	do	do	do	Flouring and grist	97	1, 616	1, 837
Do	do	do	do	Saw	25	303	396
Do	do	do	do	Locksmithing	2	29	28
Do	do	do	do	Paper	1	13	24
Do	do	do	do	Tinware, etc	1	15	20
Do	do	do	do	Wheelwrighting	1	10	10
Do	do	do	Schuylkill	Rolling	1	12	110
Do	do	do	do	Blomaries and forges	1	25	....
Do	do	do	do	Cigar-boxes	1	250	4
Do	do	do	do	Fertilizers	1	10	8
Do	do	do	do	Gunpowder	......	....	276
Do	do	do	do	Machinery	1	24	30
Do	do	do	do	Printing	1	....	3
Do	do	do	do	Saw	3	32	32
Do	do	do	do	Flouring and grist	15	232	334
Do	Delaware river	do	Philadelphia	Cotton	4	....	73
Do	do	do	do	Agricultural implements	2	42	112
Do	do	do	do	Cutlery	1	13	30
Do	do	do	do	Flouring and grist	6	77	195
Do	do	do	do	Saw	3	34	62
Do	do	do	Montgomery	Agricultural implements	1	20	20
Do	do	do	do	Cutlery	1	14	12
Do	do	do	do	Hardware	1	14	40
Do	do	do	do	Flouring and grist	17	266	365
Do	do	do	do	Saw	2	22	35
Do	do	do	Bucks	Flax	1	16	30
Do	do	do	do	Fertilizers	1	....	6
Do	do	do	do	Wooden handles	1	10	4
Do	do	do	do	Paper	1	28	35
Do	do	do	do	Plaster	1	10	15
Do	do	do	do	Cotton	1	9	45
Do	do	do	do	Sashes, doors, and blinds	2	49	50
Do	do	do	do	Saw	38	493 +	816
Do	do	do	do	Flouring and grist	89	1, 350	2, 069
Lehigh river	do	do	Northampton	Cotton	1	21	(?)70
Do	do	do	do	Blast-furnace	1	21	180 ±
Do	do	do	do	Rolling	1	21	120
Do	do	do	do	Machinery	1	21	125
Do	do	do	do	Flouring and grist	3	38	60
Do	do	do	do	Foundery	1	8	6
Do	do	do	do	Paint	1	9	30
Do	do	do	do	Slate	1	13	13
Do	do	do	do	Saw	1	4½	25
Do	do	do	Lehigh	Barrels	1	12	18
Do	do	do	do	Cement	1	8	....
Do	do	do	do	Rolling and furnace	1	8	....
Do	do	do	do	Slate	2	8	40
Do	do	do	do	Flouring and grist	3	37	....
Do	do	do	Carbon		1	8	....
Do	do	do	do	Paint	2	30	....
Do	do	do	Luzerne	Saw	4	86	290
Do	do	do	do	Foundery	1	21	30
Do	do	do	Lackawanna	Leather	1	17	60
Do	do	do	do	Saw	1	12	20
Tributaries of	Lehigh river	do	Monroe	Flouring and grist	4	66	118
Do	do	do	do	Saw	4	70	270
Do	do	do	Carbon	Blast-furnace	1	4	15

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Lehigh river	Pennsylvania	Carbon	Fertilizers	3	43	39
Do	do	do	do	Saw	16	221	299
Do	do	do	do	Flouring and grist	10	143	167
Do	do	do	Schuylkill	Saw	4	59	45
Do	do	do	do	Leather	1	15	5
Do	do	do	do	Flouring and grist	6	......	64
Do	do	do	Northampton	Agricultural implements	4	53	42
Do	do	do	do	Hardware	1	6	8
Do	do	do	do	Machinery	1	14	15
Do	do	do	do	Slate	2	24	22
Do	do	do	do	Flouring and grist	43	676	1,004
Do	do	do	do	Saw	6	63	81
Do	do	do	Berks	Flouring and grist	4	76	82
Do	do	do	do	Leather	1	5	9
Do	do	do	Lehigh	Agricultural implements	1	6	8
Do	do	do	do	Carriage materials	4	57	57
Do	do	do	do	Fertilizers	1	12	18
Do	do	do	do	Foundery	1	10	16
Do	do	do	do	Flouring and grist	63	974	1,232
Do	do	do	do	Cooperage	1	19	16
Do	do	do	do	Leather	2	21	20
Do	do	do	do	Saw	12	165	170
Do	do	do	do	Machinery	1	7	10
Do	do	do	do	Mantels, slates, etc	2	13	22
Do	do	do	do	Water-works	1	6	......
Other tributaries of	Delaware river	do	Northampton	Agricultural implements	2	22	28
Do	do	do	do	Fire-arms	1	16	32
Do	do	do	do	Planing	1	11	40
Do	do	do	do	Marble and stone work	2	23	62
Do	do	do	do	Paint	1	7	40
Do	do	do	do	Slate	6	47+	72
Do	do	do	do	Wheelwrighting	1	......	2
Do	do	do	do	Flouring and grist	28	432	961
Do	do	do	do	Leather	1	12	12
Do	do	do	do	Saw	10	191	236
Analomink creek	do	do	Monroe	Fertilizers	1	8	12
Do	do	do	do	Machinery	1	4½	10
Do	do	do	do	Leather	1	15	15
Do	do	do	do	Flouring and grist	3	33	83
Do	do	do	do	Saw	4	82	155
Other tributaries of	do	do	do	Woolen	2	......	55
Do	do	do	do	Agricultural implements	2	32	30
Do	do	do	do	Blacksmithing	1	10	22
Do	do	do	do	Carriage materials	1	13	30
Do	do	do	do	Emery-wheels	1	23½	130
Do	do	do	do	Foundery	1	14	20
Do	do	do	do	Sporting goods	1	9	2
Do	do	do	do	Slate	2	24	35
Do	do	do	do	Sashes, doors, and blinds	1	14	75
Do	do	do	do	Leather	2	......	32
Do	do	do	do	Flouring and grist	23	344	679
Do	do	do	do	Saw	5	72	79
Paupack creek	Lackawaxen river	do	Pike	Leather	1	40	40
Do	do	do	Wayne	Agricultural implements	1	9	5
Do	do	do	do	Carriage materials	1	26	25
Do	do	do	do	Wooden handles	1	16	25
Do	do	do	do	Saw	9	152	(?) 544
Do	do	do	do	Leather	1	15	75
Do	do	do	do	Silk	1	56	......
Do	do	do	do	Flouring and grist	2	52	140
Do	do	do	do	Woolen	1	10	10
Other tributaries of	do	do	Pike	Furniture	1	9	20
Do	do	do	do	Flouring and grist	2	14	25
Do	do	do	do	Leather	1	16	40
Do	do	do	do	Saw	6	92	165
Do	do	do	Wayne	Woolen	2	38	72

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Lackawaxen river	Pennsylvania	Wayne	Wheelwrighting	2	29	60
Do	do	do	do	Cutlery	1	20	50
Do	do	do	do	Saw	27	325+	700
Do	do	do	do	Leather	4	70	118
Do	do	do	do	Flouring and grist	16	275	672
Do	do	do	Lackawanna	Saw	8	46	185
Do	Delaware river	do	Pike	Agricultural implements	1	13	18
Do	do	do	do	Carriage materials	2	38	20
Do	do	do	do	Flouring and grist	5	109	113
Do	do	do	do	Leather	2	36	29
Do	do	do	do	Saw	11	......	157
Do	do	do	Wayne	Drugs and chemicals	1	10	8
Do	do	do	do	Furniture	1	10	7
Do	do	do	do	Wooden handles	1	14	35
Do	do	do	do	Toys	1	14	35
Do	do	do	do	Saw	32	605	1,038
Do	do	do	do	Leather	3	......	68
Do	do	do	do	Flouring and grist	4	73	83
Neversink river	do	New York	Ulster	Saw	5	72	155
Do	do	do	do	Leather	1	15	30
Do	do	do	do	Wooden ware	3	46	120
Do	do	do	do	Furniture	1	16	8
Do	do	do	Sullivan	Saw	4	38	100
Do	do	do	do	Leather	1	16	50
Mongaup creek	do	do	do	Saw	10	125	182
Do	do	do	do	Leather	1	17	8
Do	do	do	do	Wooden ware	1	14	20
Do	do	do	do	Woolen	1	10	10
Do	do	do	do	Flouring and grist	4	56	123
Callicoon creek	do	do	do	Saw	3	51	69
Pepacton river, or East branch of	do	do	Delaware	Woolen	1	4	7
Do	do	do	do	Cooperage	1	3½	4
Do	do	do	do	Foundery	1	4	10
Do	do	do	do	Flouring and grist	8	34	60
Do	do	do	do	Saw	4	38	(?)105
Do	do	do	Greene	do	2	20	64
Beaver kill	Pepacton river	do	Sullivan	do	4	39	80
Do	do	do	do	Leather	2	18	124
Do	do	do	do	Wooden ware	1	10	30
Do	do	do	do	Flouring and grist	1	9	32
Do	do	do	Ulster	Saw	1	29	50
Do	do	do	do	Wooden ware	1	20	30
Other tributaries of	do	do	Sullivan	Saw	7	64	251
Do	do	do	do	Leather	2	28	116
Do	do	do	do	Wood-turning	1	11	24
Do	do	do	do	Wooden ware	1	27	30
Do	do	do	do	Flouring and grist	1	18	25
Do	do	do	Delaware	Woolen	1	14	6
Do	do	do	do	Agricultural implements	1	18	6
Do	do	do	do	Drugs and chemicals	1	......	8
Do	do	do	do	Flouring and grist	8	126	190
Do	do	do	do	Saw	40	650	1,200
Do	do	do	do	Leather	4	......	67
Do	do	do	do	Planing	1	21	10
Do	do	do	do	Machinery	3	49	24
Do	do	do	do	Sashes, doors, and blinds	2	18	14
Do	Delaware river	do	Orange	Planing	1	28	20
Do	do	do	do	Plaster	1	18	25
Do	do	do	do	Sashes, doors, and blinds	1	29	40
Do	do	do	do	Carriage materials	1	18	30
Do	do	do	do	Flouring and grist	4	78	110
Do	do	do	do	Furniture	1	......	19
Do	do	do	do	Saw	1	14	25
Do	do	do	Sullivan	do	38	574	708
Do	do	do	do	Leather	2	26	40
Do	do	do	do	Wheelbarrows	1	22	40
Do	do	do	do	Wood turning	2	26	43

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Delaware river	New York	Sullivan	Cooperage	1	9	16
Do	do	do	do	Excelsior	2	41	80
Do	do	do	do	Furniture	1	10	10
Do	do	do	do	Paper	1	18	15
Do	do	do	do	Flouring and grist	18	351	503
Do	do	do	Delaware	Saw	3	34+	72
West branch of	do	do	do	Woolen	3	28	34
Do	do	do	do	Agricultural implements	1	11	5
Do	do	do	do	Cooperage	2	17	7
Do	do	do	do	Cutlery	1	5	[illegible]
Do	do	do	do	Furniture	1	11	3
Do	do	do	do	Hardware	1	3	8
Do	do	do	do	Flouring and grist	6	72	188
Do	do	do	do	Saw	9	84	117
Do	do	do	do	Leather	2	26	25
Do	do	do	do	Machinery	1	19	11
Do	do	do	do	Wooden ware	1	5	6
Tributaries of	do	do	do	Woolen	1	20	26
Do	do	do	do	Carriage	1	18	20
Do	do	do	do	Cooperage	2	17	13
Do	do	do	do	Drugs and chemicals	1	2	[illegible]
Do	do	do	do	Furniture	2	......	(?) 22
Do	do	do	do	Flouring and grist	11	198	336
Do	do	do	do	Saw	20	312	431
Do	do	do	do	Leather	2	....	35
Do	do	do	Broome	Flouring and grist	1	9	45

VIII.—THE COAST STREAMS OF NEW JERSEY.

Under this head will be considered the remaining streams in the district assigned to me, comprising all those flowing into the Atlantic ocean from the state of New Jersey, or between cape May and the Hudson river. Of these streams, those draining the southern part of the state differ considerably in character from those draining the northern part; and to understand clearly the cause and the nature of this difference, it will be necessary to consider for a moment the general features of the topography and geology of the state. In the introduction to this report attention has already been called to the fact that the system of the Alleghanies approaches very near the coast in northern New Jersey, so that the Atlantic plain, which bounds that system on the east, lying between it and the ocean, although some 50 miles wide in New England, and very much wider south of the state of Pennsylvania, almost vanishes near the mouth of the Hudson. Of the three divisions into which the Atlantic water-shed may be divided, namely, the mountainous or western, the middle, and the eastern, and which are so well marked in the southern states, the eastern almost disappears in the northern part of New Jersey, and the middle one is reduced to a narrow strip, averaging only 20 miles in width through the state, from the Hudson to the Delaware, so that the mountain region, although not so high or so broken as toward the south or the north, borders almost on the coast. Extending across the state from northeast to southwest, and including all the northern and northwestern part of the state, it is separated from the coast by the narrow middle region just referred to, and, beyond the fall-line, by a plain belonging to the eastern division, varying in width from nothing at the north to 50 or 60 miles at the south, and including all the southern and southeastern part of the state. But, as has already been remarked in the introduction, this eastern division is not by any means so low and flat as the eastern division in the southern states. On the contrary, the divide which lies in that division, and forms the water-shed between the streams flowing directly to the ocean, and those tributary to the Delaware river, has an average elevation of from 160 to 190 feet, and lies at a distance from the sea of from 20 to 40 miles only, so that the slope toward the ocean is between 4 and 7 or 8 feet per mile. As we cross the state from south to north, then, we encounter first a comparatively level or gently sloping plain, covering the entire southern part of the state; then we cross the fall-line, and after passing over the middle region we come to the Appalachian chain, with its broad belt or series of ridges, which cross the state from southwest to northeast, and occupy all its northern and northwestern parts. The boundaries of these three divisions may be indicated approximately as follows: The fall-line, which forms the boundary between the eastern and the middle division, lies almost in a straight line between Trenton and Jersey City, while the boundary between

the middle and western divisions is the first range of hills which we may consider to belong to the latter, namely, that formed by Mine mountain, Trowbridge mountain, Stony Brook mountain, and Ramapo mountain. Geologically, the eastern division belongs to the Tertiary and Cretaceous formations, and the soil is sand, gravel, clay, and marl; the middle division is Triassic, the rocks being red sandstone, but intercepted by numerous trap ridges, whose general direction is nearly northeast and southwest; and the western division belongs to the Azoic and Paleozoic formations. The difference between the northern and the southern streams is now easily understood. The former have considerable fall, and although their declivities are often uniform on account of the large masses of drift through which their courses lie, yet, where they cross the trap ridges, and the outcrop of other hard rocks, they sometimes show concentrated falls of considerable magnitude. The southern streams, on the contrary, belong, to a certain extent, to the class of sand-hill streams; they have no precipitous falls, they flow with uniform declivities in beds of sand and gravel, and in general they flow directly down hill by the line of steepest descent, nearly at right angles to the coast, their courses being independent of geological configuration, and their beds being simply channels scooped out in the movable deposits in which they lie. As the characteristics of the sand-hill streams will be fully explained when speaking of some tributaries of the Cape Fear, it is unnecessary to refer to them here in detail; but the most important facts are that their flow is very constant, and that the topography of the region which they drain is favorable to storage, so that large reservoirs can be formed, and the power available very largely increased in that way.

In order to understand clearly the character of the more northern streams, the topography of the western and middle divisions must be described rather more at length. That part of the Appalachian chain which lies in New Jersey consists of two principal ranges, the Blue or Kittatinny Mountain and the Highland range. The former, known in New York as the Shawangunk, and in Pennsylvania as the Kittatinny Mountain, extends in an almost unbroken ridge from the New York state line to the Delaware water-gap, and is the highest land in the state, varying from about 900 to 1,800 feet in height. The Highland range, on the contrary, "is composed of a great number of mountain ridges, and while it occupies a belt of country 22 miles wide on the New York state line, and 10 miles wide on the Delaware, it really includes no long, unbroken ridges, except the Green Pond mountain range; and the subordinate ridges of which it is composed are not really in line with each other, nor are their axes parallel to the direction of the main range, but are somewhat oblique to it, so that if the direction of the range is northeast, that of these ridges would be about north-northeast. The effect of this peculiar arrangement is to make it possible to cross from one side of the range to the other in a north-northeast direction without surmounting any considerable elevation, while it is impossible to cross it from southeast to northwest without rising over a succession of steep and high mountain ridges". The range is lowest at the Delaware, and gradually rises toward the New York state line, its highest point being 1,488 feet above the sea. The ranges vary greatly in surface, but are much smoother and more rounded in outline than the Kittatinny Mountain; and while many are deeply covered with earth, others are of loose stone or bare rock. The existence of these ridges, parallel but not continuous, serves in many cases to explain the courses of the rivers, often very crooked.

The middle region, or red-sandstone district, "like that of Massachusetts and Connecticut, as well as those of New York and Pennsylvania, is traversed by various and irregularly-distributed ridges of trap-rock. These rough, rocky, and wooded ridges are remarkable from their occurrence in the midst of a rich, highly cultivated, and productive agricultural district. The principal of these ridges are, Sourland mountain, in Hunterdon and Somerset counties; Rocky Hill, in Somerset; Round Valley mountain, in Hunterdon; Bergen hill and Palisade mountain, in Hudson and Bergen counties, and the First, Second, and Third mountains, which form the long, narrow, and parallel ridges that rise in Somerset and run across Union, Essex, Morris, Passaic, and Bergen counties. They are rough in outline, very abrupt in their descent toward the southeast, and gentle in their slope toward the northwest".(*a*) Being composed of hard and durable rock, occurring in the midst of the soft red sandstone, they are of great importance as regards the water-power of the streams which cross them, and many of the large falls are due to them.

In the southern half of the state, below the fall-line, there are no rocky eminences, and the rounded hills are all of earth.

The valleys between the ranges of mountains in the northern half of the state are covered, and in some places to a considerable depth, with beds of drift, through which the rivers have cut out their channels, reaching, in places, the rock. The valleys offer in many places sites for the construction of storage reservoirs, although the topography is not particularly favorable in this respect; but the flow of the streams is to a certain extent regulated by the numerous lakes and ponds already existing.

These remarks and quotations will serve to give a general idea of the topography of the country; and we now proceed to consider in detail the various streams flowing into the Atlantic, beginning at the south. Regarding those lying below the fall-line, there is little to be said except to refer to the powers utilized. These declivities being uniform as a rule, there are no falls of note, and no sites can be specially mentioned, except a few which have at some time been utilized, and where it is therefore known that power can be obtained. Dams are always necessary, of course, and, generally, only small falls can be utilized.

a The quotations above are from Professor Cook's *Report on the Geology of New Jersey,* to which I am greatly indebted.

The first important stream is the Great Egg Harbor river, which takes its rise in the southern part of Camden county, flows in a southeasterly direction, forming for a short distance the boundary between Camden and Gloucester counties, and afterward flowing through Atlantic county into Egg harbor, an inlet of the ocean. Its length is 41 miles, and it drains a total area of 425 square miles, lying entirely below the fall-line. It is tidal and navigable as far as the town of May's Landing, about 15 miles from the ocean, at which place occurs the first power on the river. Above this point the stream is utilized to a considerable extent, the bed is sand and gravel, the banks are generally low but seldom overflowed, the declivity is gradual, and the ponds are large. No data regarding its flow or declivity could be obtained, except such as follow from the data obtained regarding power utilized.

The power at May's Landing is obtained by damming the stream to a height of about 11 feet, by which the water is ponded over an area of about 1,000 acres to an average depth of 10 or 11 feet, so that considerable storage is afforded. The dam is of earth, about 12 or 13 feet high, and crosses the stream in a broken line, with a total length of about 1,000 feet. Near the center is a stone overfall, about 125 feet long (not included in length of dam) and 11 feet high. The dam was first built many years ago, but was gradually increased in height in order to obtain a larger pond. Although the stream is not subject to very heavy freshets, nevertheless there was one on September 15, 1878, of such violence as to wash out the dam almost completely, carrying away two-thirds of the earthen dam and the entire stone dam, and causing an amount of damage estimated at $13,000. The mills were not injured. In 1879 the dam was rebuilt more solidly than before, but the effect of the freshet in washing out the old dam was to fill up the bed of the river below, so that vessels of 6 or 7 feet draught, which could previously come up almost to the railroad bridge, were obliged to land half a mile or so farther down. The race leading to the wheels is about 500 feet long, 40 feet wide, and 10 feet deep, and the fall used is about 11½ feet, with a power of 120 horse-power utilized. This power can be obtained all the time, the mill being run sixty-four hours a week and no steam-power being used. In fact, there is always a little waste in summer at night. The power is owned by the May's Landing Water Power Company, but at present no power is leased to other parties, all that is used being for the cotton-mill of the company. In regard to the dam, it should further be mentioned that the stone overfall is founded on piles, and that the bed of the stream in front of it is protected by an apron.(*a*)

The drainage area above May's Landing is about 190 square miles. If we take the gross power utilized as 180 horse-power, with a fall of 11½ feet, we find the flow to be about 140 cubic feet per second, or about three-quarters of a cubic foot per second per square mile. As this can be obtained all the time and with always some little waste in the dry season during the night, it is reasonable to conclude that the low-season flow is in the neighborhood of half a cubic foot per second per square mile; so that we may perhaps take the flow of the sand-hill streams of New Jersey as varying between half a cubic foot and one cubic foot per second per square mile, or the same as in the case of the sand-hill streams in the southern states (see pages 61, 62, 84, 85, 97, and 132 of the report on the southern Atlantic water-shed).

The next power, as the river is ascended, is at Weymouth, 5 miles above May's Landing, measured in a straight line, at which place there is a paper-mill, using about 80 horse-power, with a fall of 10 feet, together with a saw-mill, all from one dam. Details regarding the power could not be obtained.

Above this point there is said to be no utilized power of much consequence on the stream, although there are a few small mills scattered about on the various tributaries. The table on pages 137 to 140 gives the statistics of power utilized.

It would doubtless be possible to develop power at some points of the stream and on the tributaries, but no particularly good sites were heard of. On Babcock's creek, a small tributary entering at May's Landing, there is a site near the mouth, formerly in use by a grist- and saw-mill, but now idle; and there are no doubt other similar ones, but to locate and judge of them more extended surveys would of course be required.

The mills in this neighborhood are troubled little with ice or freshets, and the supply of water is comparatively constant.

The next stream requiring special mention is Little Egg Harbor or Mullicas river, which is formed on the line between Atlantic and Burlington counties by the union of several smaller streams, whence it pursues a southeasterly course, emptying into Great Harbor river. It drains a total area of 476 square miles, and its length, measured from its mouth to its sources (not to the junction of the streams just referred to), is about 42 miles. There is no power on the main stream, but on nearly all of the tributaries there are mills, and the power is considered good. Although small, these streams are capable of affording large amounts of power on account of the large storage-room obtained, but only a few scattered notes could be gathered regarding them with the time at disposal. Wading river, the first important tributary, enters from the north, is about 28 miles long, and drains a total area of 140 or more square miles. Its most important power is at Harrisville, on the East branch, where there is a paper-mill using a fall of about 12 feet and about 140 horse-power. A large pond is formed, so that considerable storage is obtained. It is also said that the West branch of the stream, which naturally flows into the river below the dam, is brought in above, being intercepted by a canal. The stream is navigable up to within a few miles of this place.

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a The abstracts of power used in cotton-mills, compiled from the census returns, give the fall at this place as 9 feet, and the power as 170 horse-power.

A few miles above Harrisville, on the East branch, there is a site, now unoccupied, where there was formerly a furnace and a saw-mill, said to have used a fall of 8 feet. Above this no sites were heard of, although it is probable that power could be obtained there. On the West branch there are several mills and some sites not used, one at Speedwell, where there was formerly an iron furnace, with a fall of 7 feet or so, and some others below that place. It is said that all the mills in this vicinity can run at full capacity all the year.

The two principal streams which go to form the Little Egg Harbor river are the Batsto and the Atsion river, which unite about 6 miles north of Egg Harbor city. Batsto river, the more northerly of the two, has a length of about 18 miles and drains an area of some 70 square miles. The first power is at Batsto, now not in use, but formerly used by iron-works, and a saw- and grist-mill. The fall is stated at about 10 feet and the power is considered the best in the vicinity. Farther up the stream, at the Lower Forge, is another site not in use, and still farther up others can be developed. All the dams on these streams are of earth, and they are seldom disturbed by freshets. The Atsion river, which rises in Camden and Burlington counties and forms for its entire length the boundary line between Camden and Atlantic on the south and Burlington on the north, is considerably larger than the Batsto river, draining somewhere about 150 square miles. The first power is said to be about 2 miles below the town of Atsion, where there was once a mill using a fall of 7 feet. At Atsion we come to the first utilized power—the Atsion cotton-mill. The dam, which is of earth, 600 or 700 feet long and 10 or 12 feet high, ponds the water over a hundred or more acres, and the fall used is 11 feet. The power is stated at 130 horse-power, but this can be obtained during only eleven months, even by drawing down the water in the pond during the day-time, the capacity during the remaining month being about 100 horse-power. In addition to the factory a small grist-mill and a saw-mill are run occasionally. No steam is used for power, and in very dry weather the mill is sometimes obliged to stop. It is said that the pond is connected by a canal with the Mechesatauxen river, a stream flowing nearly parallel with the Atsion, and joining it at a distance of 8 or 10 miles below, so that an additional supply of water is obtained in this way. Above this place there are only very small powers on the stream.

Some of the tributaries of Atsion river have small mills, but none are large enough to merit special description.

The next stream above Little Egg Harbor river is Cedar creek, which is 20 miles long and drains 70 square miles. The next is Tom's river, a larger stream, about 30 miles long and draining about 150 square miles above the village of Tom's River, and with some power utilized and probably some undeveloped. The next is the Metedeconk river, about 22 miles long, and draining about 100 square miles. This stream has two branches which join about 3 miles below Bricksburg, and below the junction there is no power worth mentioning, the tide coming up to within a mile or so of that point; but there was once a forge just above the head of tide-water, with a fall of about 9 feet, it is said. On the North branch there are a few small grist- and saw-mills, but the stream is said to be not so constant as the South branch. On the latter there are several powers. About 2 miles below Bricksburg there was once a saw-mill, now not in use, and at Bricksburg is the best site on the stream. It was used until within a few years by a machine-shop, foundery, blacksmith-shop, and saw-mill, and the dam is still in good condition. It is of earth, about a quarter of a mile long and 10 feet high, serving at the same time as a wagon-road. The overfall is about 20 feet long, and the pond covers probably 20 acres. The fall was about 9 feet, and it was stated that the flow is remarkably constant. There is some power on the stream above this, but it is not important. In fact, the drainage area above Lakewood is in the neighborhood of only 25 square miles; so that the power at that place would presumably not exceed 3 or 4 horse-power per foot fall in very dry seasons, even if the water were stored during the night.

There are no other streams worth mentioning south of the Raritan, so that those just described, together with the lower tributaries of the Delaware, comprise all the streams in the eastern division in the state. The rainfall over all this region is about 48 or 50 inches, of which about 12 inches fall in each season.

We now come to the streams which lie principally in the middle and western divisions, not belonging to the class of sand-hill streams.

THE RARITAN RIVER.

This stream, the largest in the state, is formed by the union of two branches, the North branch and the South branch, which unite in Somerset county, whence the stream pursues a general easterly course, passing into Middlesex county, flowing past the city of New Brunswick, the most important city on the stream, and emptying into Raritan bay at the southern extremity of Staten island. The only important towns by which it flows, above New Brunswick, are Bound Brook, Somerville, and Raritan. The length of the river from the junction of its forks to its mouth at Perth Amboy is about 22 miles in a straight line. The total length of the stream (probably from its headwaters) is given by Professor Cook as 80 miles. Its total drainage area is between 1,000 and 1,100 square miles, distributed nearly as follows among its principal tributaries:

	Square miles.
North branch (length, 30 miles)	180
South branch (length, 50 miles)	280
Millstone river, from the south (length, 35 miles)	250
Green brook, from the north (length, 15 miles)	63
South river, from the south (length, 30 miles)	122

The total drainage area above New Brunswick, which is at the head of navigation and of tide-water, and one terminus of the Delaware and Raritan canal, is about 850 square miles.

The sources of the Raritan lie in what we have called the western division. The South branch takes its rise in Budd's lake, a beautiful and nearly circular sheet of water lying in the highest part of the Highlands, at a height above the sea of somewhere about 900 feet and measuring about 3½ miles in circumference. From this source the South branch pursues a circuitous course, flowing first toward the southwest, but gradually bending to the east; it has a rapid fall and drains a hilly and broken country. The North branch rises on the Succasunny plains, at an elevation above the sea of about 725 feet, and is more sluggish than the South branch, draining a more level country. From the junction of the two to the sea the course of the Raritan lies through the middle division, and its fall is not great, as the following table shows:

Table of declivity of the Raritan river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0			
			14	0	0.0
New Brunswick	14	0			
			5	21	4.2
Bound Brook, crossing of Lehigh Valley railroad.	19	21			
			5	18	3.6
Near Somerville	24	39			
			6	16	2.7
Junction of two branches	30	55±			

The stream crosses the fall-line a few miles above New Brunswick, but the fall thereby occasioned is not large. The first canal-dam of the Delaware and Raritan canal, which affords inland water communication between New Brunswick and Bordentown, on the Delaware, is located at this point, and will be referred to together with the power obtained from it at New Brunswick. As in the case of the streams as far south as the James, the fall-line is only a little above the head of tide-water. The eastern part of the Atlantic plain, at the place where the river crosses it, is very narrow, and it gradually disappears toward the north, while toward the south it widens; so that some of the southern tributaries of the Raritan belong to a certain extent to the class of sand-hill streams, and are used to a considerable extent for power. Such are South river, Lawrence brook, and the Millstone river, the two former emptying below New Brunswick, and the latter, although emptying some miles above that place, with its headwaters in the eastern division. The topography of the state in and around the basin of the Raritan is rather curious. Between Perth Amboy, on Raritan bay, and Trenton, on the Delaware, the width of the state is smaller than anywhere else—between 30 and 35 miles—yet from Trenton all the way up to the Musconetcong valley the ridge or water-shed between the Raritan and the Delaware is at a distance of only about 9 miles from the latter stream, and its direction is nearly northwest and southeast, or parallel to the Delaware river, instead of northeast and southwest, the general direction of the water-shed between the Delaware and the Atlantic, in the state, both north and south of the Raritan. North of the Raritan there are few, if any, real sand-hill streams, either in New Jersey or in the New England states, and the fall-line borders almost on the coast in this whole region.

The general shape and dimensions of the basin of the Raritan, and the courses of the streams referred to, may be seen from the accompanying map. It will be noticed that the course of the Raritan is tolerably crooked, and although the distance between the source in Budd's lake and Perth Amboy is 80 miles by the course of the stream, it is only 36 miles in a straight line.

With the exception of Budd's lake, the source of the South branch, there are no lakes in the basin of the Raritan, and in this respect the stream contrasts strongly with the streams in the northern and northwestern parts of the state, whose drainage basins are dotted with ponds. It is perhaps a fair conclusion that the facilities for storage are not so great in the basin of the Raritan as in those of the latter streams; and if it were not for the fact of the existence of the southern sand-hill tributaries of the river, we should certainly be entitled to conclude that its flow is more variable and its freshets more severe than in the case of the streams referred to. Only one gauging, however, is at hand on which to base a conclusion in this respect. It is to be remarked, moreover, that the topography of the basin is not such as to facilitate a very rapid discharge of storm-waters; so that, although there are no lakes to regulate the flow, it is not probable that it is so variable as in the case of streams like the upper Potomac or James, which drain narrow and parallel valleys very favorable to a sudden discharge of the rain-water. Nevertheless, as regards those streams tributary to the Raritan which do not lie in the eastern division, though not so variable in flow as the more southerly streams just referred to, I think their flow will be found more variable than that of the more northerly streams of New Jersey. It is further to be noticed that the rainfall over the basin of the Raritan is about 48 inches, distributed as follows: Spring, 12 inches; summer, 14 inches; autumn, 12 inches; winter, 10 inches. This distribution, according to the discussion in the introduction to the report on the southern

Atlantic water-shed, is very favorable for constancy of flow; and although, on account of the comparatively small size of the drainage basin, the absolute minimum flow may reach a tolerably low figure, it is hardly to be expected that the average flow during the driest season should do so. These facts have been borne in mind in estimating the power.

The bed of the stream is in places rock, but generally it is a deposit of gravel and sand. The drift deposits, however, do not seem to be so extensive as on the Passaic and its tributaries. The facilities for dams are no doubt good, especially in the upper part of the basin. Although there are some bottoms subject to overflow, they do not seem to be extensive, and on the upper part of the North and South branches they are few in number.

The stream is very favorably situated as regards accessibility, it being comparatively easy to reach almost any part of its basin. Below the junction of the two forks the stream is within easy reach from several railroads, and up to the mouth of the Millstone it is closely followed by the canal. The portion of the basin drained by the North branch is the least accessible of any, but it will be seen that the water-power of this stream is not of very great importance.

As the river is ascended, the first dam we meet is that of the Delaware and Raritan canal, situated about 5 miles above New Brunswick, and supplying the lower level of the canal with water. This dam, and that at Bull's falls on the Delaware, at the head of the feeder-canal, are the only dams by which the canal is supplied, so that the water from the Delaware river literally flows through the canal over the water-shed between that river and the Raritan, the highest point of the canal being only 57 feet above tide, this being the lowest point in the water-shed separating the Delaware from the ocean. South of the summit of the canal the height of the water-shed increases to 200 feet, and preserves this elevation along the center line of the state as far south as Cumberland county. The dam above New Brunswick is of crib-work, pointed up stream, and is about 800 feet long and 10 feet high. It was built between the years 1832 and 1834, and backs the water a mile or more, with an average width of 600 feet. From the New Brunswick level, fed from this dam, a race leads to the two mills of the New Brunswick Manufacturing Company, which use a fall of 12 feet, discharging the water to the lower level or basin, which is about 1½ foot above high tide. These mills manufacture hosiery, but the power used is uncertain. The method by which water is leased by the canal company has been described in speaking of the power at Lambertville on the Delaware (page 96). Although the mills receive only the surplus water, it is stated that those at New Brunswick are seldom shut off, except when the water is drawn from the canal, which is the case every year for a longer or shorter time, during which period these mills use steam-power. The quantity of water they use is stated at about 450 square inches at one mill and 540 at the other, under a head of 3 feet. No additional power is available at this place, either at the dam or at New Brunswick, for the mills above described are sometimes short of water, and it is stated that at low water there is no waste over the dam, the entire flow of the stream, except leakage, being diverted into the canal. The mean rise and fall of the tides at New Brunswick is about 5 feet.

The drainage area above the dam being about 825 square miles and the rainfall as given on page 125, I have estimated the flow and the power for a fall of 12 feet as in the following table:

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*12 feet fall.*
Minimum	825	12+	165	18.8	225
Minimum low season			210	23.9	287
Maximum with storage			825	93.8	1,125
Low season, dry years			250	28.4	340

These figures have little practical value, because all the power available without storage is now practically utilized. It may, however, enable some who are acquainted with the river to form an idea of the degree of approximation of my estimates.(*a*)

The next power met with as the stream is ascended is at the town of Raritan, above the mouth of the Millstone river and only a few miles below the junction of the North and South branches. The stream is dammed at a point about 2¾ miles above the town, the dam being of crib-work, about 175 feet long and 3½ feet high, built in a curve, founded on a bed of sand and gravel, and backing the water only a short distance. It was built about the year 1839, at a cost of $1,200 or thereabout, and is 36 feet in breadth, up and down stream, embracing 20 feet back of the crest and 16 feet in front of the same, part of which is the apron. The race leading to the town where the mills are located is said to be about 30 feet wide at the bottom and 4½ feet deep, and the total fall at the lower end is about 16 feet. The power is owned by the Raritan Water Power Company, and water is nominally leased by the

a Since writing the above, Ashbel Welch, esq., of Lambertville, president of the American Society of Civil Engineers, has given me the results of a gauging of the Raritan made by him near this point many years ago, when the river was unusually low. Mr. Welch found the flow to be 180 cubic feet per second, and, he adds: "Probably it sometimes now gets a little lower; I suppose the usual (not extreme) low-water discharge may be 250 cubic feet per second." The close agreement between this result and the figures in the table is very satisfactory.

square inch under a head of 30 inches, though in the case of the mills now in operation there seems to be no regular rate for water, the rents being determined by special agreement. The price per square foot of opening is from $300 to $400 per annum. The following mills are being supplied at present:

1. Reed & Company's grist-mill; fall, about 14 feet; uses about 50 horse-power.
2. Kenyon Brothers' foundery and machine-shop; fall, about 14 feet; uses about 10 or 15 horse-power.
3. New Jersey enamel-paint works; fall, about 14 feet; uses about 15 horse-power.
4. Adair & Company's grist-mill; fall, 14 feet; uses about 30 horse-power.

In addition to these mills a woolen-mill uses about 50 square inches, but only for washing, and not for power.

These mills can run at full capacity almost all the time. There is always a waste of water, but it is said that the canal is in poor condition, being filled up at the upper end, and that this is the cause of any lack of full supply which may and sometimes does occur. There is trouble with backwater during about a week in the year.

The drainage area above Raritan is about 450 square miles. I have, therefore, estimated the power as in the following table:

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*14 feet fall.*
Minimum	450	14	88	10.0	140
Minimum low season			112	12.7	178
Maximum with storage			450	51.1	715
Low season, dry years			135	15.4	216

I am not able to state whether there are favorable sites in the upper valleys for storage reservoirs of sufficient capacity to render the maximum with storage available, but it is probable that there are none. The facilities for the utilization of the power are good in all respects as regards location and transportation, and the site is perhaps the best on the river. Above it there are no powers except on the two branches, which will be described below.

THE TRIBUTARIES OF THE RARITAN RIVER.

South river, the first of these, enters below New Brunswick and drains about 122 square miles. It belongs to the class of sand-hill streams, and I have no details regarding its power. That which is utilized will be found tabulated on page 137. The same remarks are true regarding Laurence brook. The table of utilized power shows that the power of this stream is quite extensively utilized by small mills, among which are grist-mills, saw-mills, a tobacco factory, and a rubber factory, the last using considerable steam-power all the time. Green brook is an unimportant stream entering from the north near Bound Brook and with only a small amount of power. The Millstone river, from the south, is the most important tributary of the Raritan below the forks, and drains an area of some 190 square miles, the length of the stream being about 35 miles. Taking its rise in the western part of Monmouth county it flows in a northwesterly direction into Middlesex, forms for some distance the boundary between that county and Mercer, and finally flows nearly north through Somerset county, emptying into the Raritan 2 or 3 miles above Bound Brook. It is followed for a distance of 20 miles or over from its mouth by the Delaware and Raritan canal, and its fall in that distance is not over 35 feet, so that the stream is not very rapid, but rather sluggish. Its elevation at the railroad-crossing near Plainsborough is 54 feet above tide. Its drainage basin is flat compared with those of the northern tributaries of the Raritan, and the stream belongs in fact more to the class of sand-hill streams than to any other. Its bed is sand and clay, its flow quite constant, and it has no falls or lakes. Its power is of not much importance, though it runs a number of small mills, with falls averaging about 5 feet, and dams of about the same height. These mills are tabulated on page 137, and further particulars are not at hand.

The North branch of the Raritan takes its rise on the Succasunny plains, in Morris county, and flows nearly south, joining the South branch in Somerset. It drains a total area of about 180 square miles, and receives as its principal tributary the Lamington river. Its sources lie at an elevation of about 725 feet,(a) while that of its confluence with the South branch is about 55 feet, so that its fall is 20 feet or more to the mile. But the greater part of the fall of 670 feet occurs where the stream is too small to be used for power, and for a number of miles above its junction with the South branch it is said to be rather sluggish, and to have, in fact, no greater fall than the Raritan below the junction. The elevation at the crossing of the Central Railroad of New Jersey, about 3 miles above the junction, is 66 feet above tide. The power of the stream is not very great, according to all that could be learned, and no unimproved sites of any importance were brought to notice. The amount of utilized power can be seen by referring to the table on page 137.

The South branch of the Raritan is a stream of rather different character and much better suited for power. Rising in Budd's lake, in Morris county, it flows in a southwesterly direction through the Highland region into Hunterdon county, and gradually bending to the east flows into Somerset county, where its course is nearly north

a *Geology of New Jersey*, p. 22.

to its confluence with the North branch. While the distance of that point from Budd's lake, measured in a straight line, is only slightly over 20 miles, the length of the stream is 50 miles.(*a*) The total drainage area is about 280 square miles, lying mostly in the Highland region. The fall of the stream is much greater than that of the North branch, as will be seen from the following table:

Table of declivity of the South branch of the Raritan river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	55±	5	4±	0.8
Crossing of Lehigh Valley railroad at Neshanic	5	*a* 59	3	43	(?)14.3
Crossing of Lehigh Valley railroad at Three Bridges	8	*a* 102	7	17	2.4
Crossing of Lehigh Valley railroad at Stanton	15	*a* 119	11	116	10.5
Crossing of Central Railroad of New Jersey at High Bridge	26	235	10	273	27.3
Crossing of proposed railroad from Morristown to Easton, German Valley	36±	*b* 508	14	400±	28.6
Budd's lake, source of river	50	900±			

a I am indebted for these figures to Mr. Robert H. Sayre, superintendent and chief engineer of the Lehigh Valley railroad.
b *Geology of New Jersey*, p. 841.

By virtue of its larger fall the stream has much more power than the North branch, and its flow is probably more constant on account of the lake at its head. The declivity is generally gradual, there being no precipitous falls. The power of the stream is utilized at a number of places for mills of various descriptions, as will be seen by referring to the table of utilized power on pages 137 and 138. In Somerset county there are four mills, with an average fall of about 7 feet; in Hunterdon county we first come to six or seven flour- and grist-mills, with falls of about 6 feet each, but the falls soon become greater, and in the upper part of the county, both on the main stream and on many of its tributaries, large falls are obtained. Some of the tributaries flowing with large falls from the highland ranges, between which the South branch pursues its course, offer considerable power in comparison with their size and drainage area. Although Budd's lake is not sufficient to render uniform the flow of a large stream, such as the Raritan, or even the South branch in its lower parts, yet it is sufficient to render the upper parts of the stream much more valuable for power than they otherwise would be, and to make it possible to utilize with good effect a considerable part of the large fall which the stream possesses in its upper parts. By referring to the table it will be seen that in Morris county alone there are 22 mills on the stream, using a total fall of 322 feet, or a large part of the total fall which the stream possesses in the county. Perhaps the most important power on the stream is at High Bridge, where the Central Railroad of New Jersey crosses the stream. At this place are located the Taylor Iron Works, using power from two dams to run their forge and foundery. The upper dam, which is partly of earth and partly of crib-work, is about 20 feet high and ponds the water over 20(?) acres. A race of 500 feet leads to the forge, where the fall is 32 feet. Statements differ in regard to the power used. The lower dam is about 4 feet high, and the fall at the foundery, which it supplies, is 12 feet. A considerable amount of power is used, and it is stated that full capacity can be secured all the time.

It is probable that there are sites for power on the river still unimproved, but I can not mention any particular ones. The facilities for dams, races, and buildings are generally good, and from what has been said it will be seen that the stream is an excellent one for power. It is, moreover, very accessible throughout its whole length, and the advantages for transportation are quite good. The powers, however, are of course all comparatively small.

I have estimated in the following table the flow and power of the two branches of the Raritan at their confluence. The figures are of course not exact, in the total absence of gaugings,*a* but may serve as a means of comparison between this stream and others.

Estimated flow and power of branches of the Raritan river at their junction.

State of flow (see pages 8 to 11).	SOUTH BRANCH.			NORTH BRANCH.			RAINFALL.				
	Drainage area.	Flow per second.	Gross horse-power.	Drainage area.	Flow per second.	Gross horse-power.	Spring.	Summer.	Autumn.	Winter.	Year.
	Sq. miles.	*Cu. feet.*	*1 foot fall.*	*Sq. miles.*	*Cu. feet.*	*1 foot fall.*	*In.*	*In.*	*In.*	*In.*	*In.*
Minimum	280	50	5.7	180	30	3.4	12	14	12	10	48
Minimum low season		62	7.0		40	4.5					
Maximum with storage		300	34.1		195	22.2					
Low season, dry years		70	8.0		48	5.5					

a *Geology of New Jersey*, p. 26.

THE PASSAIC RIVER.

This important stream has its sources in Morris county, not far from the sources of the North branch of the Raritan, and its course to the sea is very crooked. Flowing first in a nearly southerly direction, and forming for some distance the boundary-line between Morris and Somerset counties, it bends quite abruptly toward the east, and pursues its course in a northeasterly and northerly direction, forming the boundary between Morris county on the west, and Union and Essex on the east, until, at the northern extremity of the latter county, it bends again abruptly and flows toward the east, between Essex county on the south and Morris and Passaic counties on the north, passing into the latter county. Bending once more near Paterson it flows nearly south between Essex county on the west and Bergen and Hudson on the east, emptying into Newark bay below the city of Newark. Although the source of the stream is distant from its mouth only 25 miles in a straight line, the course of the stream measures over 80 miles. The stream flows by the cities of Newark and Paterson and the town of Passaic, but with these exceptions there are no large towns along its course. Its crossing with the fall-line affords no fall, unless it be that at Passaic, which is at the head of tide-water and of navigation, there being a navigable depth at mean low water of 6 feet up to this place, a distance of about 29 miles.

The total area drained by the stream is about 960 square miles, according to my measurements. It is stated differently by others, and is sometimes called in round numbers 1,000 square miles. The sources of the stream lie in the western district, as do those of its principal tributaries, the Rockaway, Pequannock, and Ramapo rivers, and topographically the drainage basins of these streams are broken and rocky in their upper parts. The drainage area of the Passaic comprises a central basin with an area of about 200 square miles and a general elevation of 120 to 180 feet above tide, inclosed by the Highlands on the west and several high ridges of trap-rock on the east, through which the river breaks at Paterson and Little Falls. The tributaries named above come down from the Highland region and their basins are more broken and hilly than that of the main stream, whose course lies for some distance through the central basin just alluded to. In their courses through what we have called the middle division the streams cross a number of ridges of trap-rock, and in those places their beds and banks are rock, and generally there is a fall available for power; at other places the bed is sand and gravel, the whole valley of the stream being thickly covered with glacial drift, sometimes to a considerable depth.

The banks are in many places low and swampy and overflowed in freshets, especially on the main river in the central basin, while at others, in the upper part of the basin and where the trap ridges are cut through, they are rocky and sometimes precipitous. In all places where fall is practically available the bed and banks may be said to be favorable for the development of power.

The freshets on the Passaic and its tributaries are restrained to a considerable extent by a number of lakes and swamps which serve to regulate the flow. These lakes and swamps will be referred to more in detail when the tributaries on which they lie are considered, so that it will suffice here to state that the total area covered by lakes in the Passaic basin is about 8 square miles, while the area of swamp- or "wet" meadow-land is about 26 square miles.(*a*) The level of many of the lakes could be raised several feet without much additional flowage, and the reservoir area could in this way be increased to about 10 square miles;(*b*) many of the lakes are in fact partly artificial, and if we should calculate the area of all the mill-ponds in the basin, which are equally storage reservoirs, the above figures would be considerably increased. Were it desired to utilize as much power, and hence to obtain as much storage as possible, the most convenient way would perhaps be to raise the levels of some of these lakes; but, in addition, other storage reservoirs could be made artificially, there being several sites where they could be located. The utilization of the maximum power obtainable with storage, however, would be very expensive, as is always the case with all but very small drainage areas.

The declivity of the stream may be seen from the following table, which, however, is not very accurate:

Table of declivity of the Passaic river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0.0	0			
			29.00	0.0	0.00
Passaic	29.0	0			
			0.50	22.0	....
Crest of Dundee dam	29.5	22			
			11.50	17.0	1.50
Paterson, below falls	41.0±	39			
			1.00	76.0	76.00
Crest of Paterson dam	42.0±	115			
			5.00±	47.0	9.40
Crest of Little Falls dam	47.0±	162			
			21.75	6.0	0.29
Lower Chatham bridge	69.0±	168			
			17.00±	72.0	4.24
Near Madisonville	86.0±	240			

a Annual Report of the State Geologist, 1876, p. 44. *b Geology of New Jersey*, 1868, p. 14.

The mean annual rainfall over the basin of the Passaic is about 47 inches, distributed as follows: Spring, 11 inches; summer, 14 inches; autumn, 12 inches; winter, 10 inches—a distribution very favorable to constancy of flow in the streams. A few gaugings of flow are at hand and will be referred to in the proper place.

Beginning at the headwaters of the stream near Mendham, in the southern part of the central basin of the drainage area, we find a few small mills scattered along the stream and its tributaries as far down as Chatham. The facilities for power, however, are not very good, the fall of the streams being small and the banks frequently low and swampy. At Millington mills the stream cuts through Long hill, a trap ridge, flowing through a deep and narrow gorge, and offering some power, part of which, and perhaps all, is utilized. The drainage area above this place is only 51 square miles. From Chatham, above which the drainage area is 99 square miles, the stream flows for a distance of nearly 25 miles, down to Little Falls, with a very sluggish current through the central basin referred to, and offers no power whatever. It is bordered by low and swampy lands, all subject to overflow in times of freshet, and, as the table of declivity shows, its fall is but a little over 3 inches to the mile. On the Passaic and its branches, the Whippany and Rockaway, above Little Falls, there is in fact an area of 11,000 acres subject to overflow. Its course is quite tortuous and its bed sand and gravel. The whole valley of the upper Passaic, in fact, is filled with a thick deposit of drift, and down almost as far as Pompton, rock is never seen in the deepest excavations—some borings have been driven 300 feet without reaching it. The cause of the slight fall of the stream between Little Falls and Chatham is to be found in the dam at the former place, where the stream falls over a ledge of trap-rock known as the Second mountain, the effect of the natural dam formed by the ledge being increased by the artificial dam, which will be referred to again. For a distance of 20 miles above this dam the stream overflows its banks in times of freshet, and lays thousands of acres under water; and although attempts have been made to have this area drained, nothing has yet been accomplished.

At Little Falls we meet the first power of importance on the stream, and as the river receives the Rockaway and Pompton rivers not far above, the volume of water is very much greater than at Chatham, the drainage area above this place being about 790 square miles according to my measurements.(a) The total fall at Little Falls is stated by Professor Cook as 34 feet, and by Messrs. Croes & Howell as 32 feet, but of this only about 16 are used. The dam is stone, 280 feet long and 8 feet high, rebuilt in 1869 at a cost of $15,000; and a race 80 feet long gives a fall of 16 feet at the large carpet- and felt-mills of Mr. Robert Beattie. The power used is stated at 250 horse-power, with always a waste of water, although it is also stated that full capacity can be obtained during only eleven months, averaging two-thirds during the rest of the time. No steam-power is used. By comparing with some measurements of flow, which will be referred to again, I have estimated the power as follows:

Estimate of flow and power at Little Falls.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow, per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	16 *feet fall.*	34 *feet fall.*
Minimum	790	34	176	20.0	320	680
Minimum low season			220	25.0	400	850
Maximum with storage			780	88.6	1,418	3,012
Low season, dry years			260	29.5	472	1,000

I am not able to say whether the entire fall of 34 feet, as stated by Professor Cook, is easily available or not, but the power is evidently a very fine one.

The next power of importance on the stream, and the most important one in the state of New Jersey, is at Paterson, about 4 miles below Little Falls. Between the two places there is some fall not used, but none of importance except that already referred to, which forms part of the fall at Little Falls. At Paterson the river crosses a second trap ridge, known as First mountain, falling a perpendicular distance of 50 feet or more, the total fall in a mile being about 75 feet. Some 200 feet above the falls a dam extends entirely across the stream, ponding the water about 2 miles with a width of about 400 feet. The dam is of stone, 350 feet long and 8 feet high. For about one-third of its length its upper part consists of flash-boards, which are washed out in high water. The dam was built to a height of 4½ feet in 1837, and was raised to 8 feet in 1864, the upper part being flash-boards until the summer of 1881, when two-thirds of its length was built up in stone; it is said to have cost $13,000. The bed of the stream is rock and the banks are rather low. The total fall utilized at Paterson is about 66 feet, from three levels, the fall from each being 22 feet. The total length of canals is about 4,500 feet, and they are rectangular in section, 3 feet deep and 20 feet wide. The following is a list of the mills supplied:

I. From upper canal, 1,200 feet long:

	Square feet leased.
1. Ivanhoe Manufacturing Company (paper); fall, 22 feet	13
2. Rogers Locomotive Works; fall, 22 feet	8
3. Barbour Flax Spinning Company (flax thread); fall, 22 feet	6
4. Dolphin Manufacturing Company (flax and jute); fall, 22 feet	9
Total square feet leased from first level	36

a 750 square miles according to Professor Cook, and 832.75 according to Messrs. Croes & Howell (*Report on Additional Water Supply for Newark*).

II. From second level, 1,600 feet long:

	Square feet leased.
1. J. H. Booth & Co. (silk); fall, 22 feet	4
2. Grant Locomotive Works; fall, 22 feet	3
3. Danforth Locomotive Works; fall, 22 feet	8
4. Hamil & Booth (silk); fall, 22 feet	7
5. Hopper & Scott (silk); fall, 22 feet	3
6. Robert Adams (silk); fall, 22 feet	2
7. Franklin Manufacturing Company (machinery); fall, 22 feet	$1\frac{1}{2}$
8. R. & H. Adams (mosquito-netting); fall, 22 feet	8
9. John Ryle (silk); fall, 22 feet	2
Total square feet leased from second level	$38\frac{1}{2}$

III. From third level, 1,300 feet long:

1. Franklin Manufacturing Company (calico-printing); fall, 22 feet	7
2. Todd & Rafferty Manufacturing Company (machinery); fall, 22 feet	3
3. James Mussey (machinery); fall, 22 feet	2
4. Phœnix Manufacturing Company (silk); fall, 22 feet	$5\frac{1}{2}$
5. R. & H. Adams (mosquito-nets and silk); fall, 22 feet	14
6. Globe Mill Company (silk); fall, 22 feet	3
7. Machinists' Association (machinery); fall, 22 feet	2
Total square feet leased from third level	$36\frac{1}{2}$

IV. On overflow from lower level, 400 feet long:

1. Paterson grist-mill; fall, 12 feet	1

The total gross power utilized at these mills is about 2,350 horse-power. In dry weather there is no waste over the dam, even at night, and most of the mills run during only the day-time, or about ten hours. In dry weather the company shuts off the water from the mills from 7 p. m. till 6 a. m. The mills can obtain their full capacity during only about nine months of the year, and almost all of them have supplementary steam-power for the rest of the time, while a few use some steam-power continuously. During about three months the mills can obtain only about three-quarters of their full capacity; while during about eight months there is a waste over the dam in the day-time. It must be remarked, however, that some water is allowed to pass the dam to supply the pump-works below, so that not quite the entire flow is available for power.

The power at Paterson is owned and controlled by the "Society for Establishing Useful Manufactures", an association incorporated in 1791; and it was one of the earliest of the large powers in this country which was developed and utilized for manufacturing to any considerable extent. Water is leased by the company at the rate of $750 per square foot under a head of 3 feet, delivered through a sharp-edged orifice 6 inches high, at the bottom of the canal. This amounts to about 8.5 cubic feet per second, equal to $21\frac{1}{4}$ gross horse-power with a fall of 22 feet; so that the price per annum per gross horse-power is nearly $36, or $88 per cubic foot per second, a very high rate compared with that at other places where large amounts of power are leased. No detailed measurements, however, are made to determine the exact quantity of water used by each mill, except when a new wheel is put in, or when the company has reason to suspect that an excess of power is being used. The water is gauged for overshot wheels by orifices in the flume; while for turbine wheels the apertures in the wheel are used in determining the quantity, the aperture corresponding to a square foot under a 3-foot head being taken for the turbines as 53.18 square inches, this bearing the same ratio to 144 that the square root of 3 does to the square root of 22. No deduction is made from the price on account of a lack of water at times; and, in fine, the power is only roughly controlled compared with the care which is exercised in Lowell, Lawrence, and other places.

Below the dam, which has already been described, at the head of the principal fall, and extending in a zigzag line across the stream, is a second dam, averaging perhaps 5 feet in height, and used simply for the purpose of supplying power and storing the water for the city pumping station, which is situated on the left bank of the river just above the fall. The dam is of stone, with 23 inches of flash-boards on top. It was originally built many years ago, but was raised in 1881 to increase the storage. At present it ponds the water up to the upper dam, which is provided with gates, through which water is let down for the supply of the city, and is pumped by water-power during from seven to nine months, steam being used partly or wholly during the rest of the time. The wheel-pit is a chasm in the natural rock, the fall is 30 feet, and the power 120 horse-power. The amount of water pumped is in dry weather about 7,000,000 gallons in twenty-four hours, or 14 cubic feet per second.

The minimum flow of the Passaic river at Paterson is stated by Messrs. Croes & Howell at 195 cubic feet per second, and the maximum at Passaic at 17,913 cubic feet per second. I have estimated the following table from these data:

Estimated flow and power at Paterson.

State of flow (see pages 8 to 11).	Drainage area.	Fall used.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	22 *feet fall.*	66 *feet fall.*
Minimum	813	66	195	22.2	488	1,465
Minimum low season			246	28.0	616	1,848
Maximum with storage			800	90.9	2,000	6,000
Low season, dry years			287	32.6	717	2,150

These figures are estimated, of course, like all the others in this report, for the natural flow of the stream, taking the average for twenty-four hours. If the water is stored during the night the power could be much increased. The entire fall of 22 feet from the lower level, however, is not entirely used, and some deduction must be made for the water used by the city. Still it is difficult to understand how, if the above figures are at all correct and the mills are using only a gross power of 2,350 horse-power, they should run short at all. It is to be regretted that more reliable and detailed information regarding the flow of the stream, and the power utilized, by which these discrepancies could be reconciled, is not at hand.

The power at Paterson, as regards commercial facilities of all kinds, can not be excelled, and to it the prosperity of the city is no doubt chiefly due.

As the Passaic river is further descended, the last important power on the stream, situated at the head of tide and navigation, is at Passaic. The dam, 2 miles above the town, is of stone, stepped in front, and extends across the stream in an arc of a circle, the chord being 450 feet and the center ordinate 7 feet. It is 14 feet high, and was originally built in 1858, at a cost, it is said, of $250,000, but was extensively repaired in 1880. It is founded on a sandstone ledge, and has never been much injured by freshets or ice. It ponds the water for about 4 miles, with an average width of about 500 feet. The tide is felt up to within half a mile of the dam. The race is nearly 2 miles long and 80 feet wide. The power is owned and controlled by the Dundee Water Power and Land Company, and the following mills are supplied: The Passaic print-works, Basch & Co.'s woolen-mill, Reid & Barry's print-works, the Rittenhouse Manufacturing Company, the New York steam-engine works (not running at present), an oil-cloth works, Waterhouse Brothers' woolen-mill, and the city water-works. The fall varies with the tide from 20 to 24 feet, averaging 22 feet. Power is leased by the "mill-power", which is defined as 8½ cubic feet per second under a fall of 22 feet during twelve hours in the day, the regular price being $700 per mill-power per annum, or about $33 33 per gross horse-power, a rate nearly as high as that at Paterson. The whole number of mill-powers leased is at present 62, including 20 mill-powers leased to a large rubber factory now being built. As a mill-power is equal to about 21 gross horse-power, the power leased is about 1,300 horse-power, that used being about 882 horse-power. Full capacity has generally been secured all the time, though there has sometimes been a slight scarcity for a few weeks. In very dry weather there is no waste at night, but generally there is some waste at all seasons. No steam-power is used to supplement the water-power, but some of the mills use steam all the time. The city water-works takes its water-supply, consisting of one mill-power, from the canal, pumping it by steam. The amount of water taken by the mills is not controlled accurately, no attempt at measurement being made, and the amounts paid for being based on measurements made some years ago by Mr. William E. Worthen. It is thought probable that more water is used than is paid for, but on account of there being an excess of power, no trouble has occurred. The company does not lease water except during the day-time, but most of the mills run somewhat at night, though the company can prevent their doing so if it so choose. I have estimated the power at Passaic as follows:

Estimated flow and power at Passaic.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	22 *feet fall.*
Minimum	908	22	211	24.0	528
Minimum low season			264	30.0	660
Maximum with storage			900	102.3	2,250
Low season, dry years			320	36.4	800

This power, though small, is an excellent one in every respect.

THE TRIBUTARIES OF THE PASSAIC RIVER.

The first tributary we meet in ascending the stream is *Saddle river*, a small stream, but utilized very extensively for mills of various kinds, as the table of power shows. The next tributary is the *Pompton river*, which enters at Two Bridges just above Little Falls. This stream is formed by the union of the Pequannock, Ringwood, and

Ramapo, and is only about 5 miles long. It offers no power at all, and it is only on its tributaries that any is available. The *Ramapo river* takes its rise in Orange and Rockland counties, New York, and flows in a general southerly direction through Bergen county, draining about 172 square miles comprising a very broken and rugged country. "At the headwaters of the stream, near Turner's, there is a small limestone region of about 8 square miles area; the base rock of the rest of the water-shed is gneiss, except the eastern slope of the lower 15 miles of the stream, which is red sandstone."(*a*) The river is fed by the following-named lakes and ponds: (*b*)

1. Franklin lake, New Jersey: area, 94 acres; drainage area, 1,000 acres; perhaps connected with Crooked lake, which covers 30 or 40 acres, and The Ponds, by subterranean channels.
2. Rotten pond, New Jersey: area, 20 acres; drainage area, 1,200 acres.
3. Negro pond, New Jersey and New York: area, 100 acres; drainage area, 900 acres.
4. Truxedo pond, Little Long pond, Mount Bashon pond, Island pond, Slaughter pond, Cranberry pond, and Round pond, all in New York, are small sheets of water, regarding which no data are at hand.

Of these ponds some are dammed, but it is not probable that they exercise much influence on the flow of the river. The power used on the stream is tabulated beyond. The most important site is that at Pompton, where the steel-works are located, the fall being 20 and 24 feet. It is said that 250 horse-power are utilized during six months. At Ramapo, New York, there were formerly iron- and nail-works, using a fall of 18 feet, but no mill is there now; this is the only important unimproved power on the stream which was brought to my notice.

The *Ringwood river* rises in Orange county, New York, and flows through Passaic county, New Jersey, draining about 108 square miles. It is fed by the following-named lakes and ponds:

1. Mud pond, New Jersey: area, 50 acres; drainage area, 1,600 acres.
2. Tice's pond, New Jersey: area, 40 acres; drainage area, 800 acres.
3. Shepherd's pond, New Jersey: area, 90 acres; drainage area, 1,000 acres.
4. Greenwood lake, New Jersey and New York: area, about 4 square miles; drainage area, 32 square miles. This lake is one of the feeders of the Morris canal, and is dammed to a height of 13 feet.
5. Besides Sterling pond, New York, regarding which no data are at hand, there were several large ponds on the Ringwood river itself, between Boardman and Winokee, mostly artificial, but the dams are said to be going to ruin. The power was used for blast-furnaces and forges, some of which are not now in operation. Other than the data given in the table of utilized power I have no information regarding the power of the stream. As Greenwood lake is not heavily drawn upon to supply the canal, it would seem probable that the flow of this stream might be made comparatively uniform, and its water-power of considerable value.

The *Pequannock river* rises in Morris, Passaic, and Sussex counties, New Jersey, and forms for its entire length the boundary between Morris and Passaic. It drains, above the mouth of the Ringwood, some 90 square miles. The basin resembles that of the Ramapo, and the stream is fed by the following-named lakes and ponds:

1. Macopin pond, or Echo lake: area, 363 acres; drainage area, 1,700 acres; dammed, and can be drawn down 4 feet; drainage area could easily be increased to 3,200 acres.
2. Hank's pond: 80 acres; drains 4 square miles.
3. Cedar pond: 96 acres; drains 800 acres.
4. Duck Mountain pond, Dunker pond, Canistear pond, Pine Hammock pond, Timber Brook pond, and Stickle's pond are small sheets of water, some of them partially or wholly artificial, and serving a useful purpose as regulators. The stream offers considerable power, a portion only of which is utilized. The fall is rapid, the banks are high, and the flow is quite uniform. As few data regarding elevation are at hand, I can give no figures regarding the power available; but as the head-waters of the stream in the swamp near Snufftown lie at an elevation of 1,025 feet, while at Bloomingdale the elevation of the stream is only 258 feet, the fall is evidently very large. There must also be considerable power available between Bloomingdale and Little Falls. That utilized is tabulated on page 138. At Bloomingdale the Rubber Comb and Jewelry Company uses a power of 100 horse-power all the time, and 300 horse-power during five months, with a fall of 32 feet, and the figures, which agree well with those given by other manufacturers, give the average low-season flow as about 30 cubic feet per second during working hours, or about fifteen as the natural flow of the stream.

The *Rockaway river* rises in the eastern corner of Sussex county, flows first in a southwesterly direction as far as Port Oram, where it bends to the east, and flows nearly east, passing the towns of Dover and Boonton. Its drainage basin is broken and rocky and its fall rapid, so that a large amount of power is available. The stream is fed by a few lakes, but they are not large enough to do very much to regulate its flow. They are as follows:

1. Split Rock pond covers 237 acres and drains 6¼ square miles. It is already dammed. Its height above tide is 815 feet.
2. Durham pond covers 65 acres, drains 1,000 acres, and is also dammed.
3. Green pond covers 560 acres and drains 2½ or 3 square miles. Its height above the sea is 1,069 feet.
4. Denmark pond covers 175 acres and drains 2½ or 3 square miles.

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a Newark Aqueduct Board. *Report on Additional Water Supply*, p. 16.
b *Annual Report of the State Geologist*, 1876.

5. Middle Forge pond covers 70 acres.

6. Dixon's Forge pond covers 60 or 75 acres and drains $1\frac{1}{2}$ or 2 square miles.

7. Shongum pond covers 125 acres and drains $2\frac{1}{2}$ or 3 square miles. Some of these ponds besides the two already specified are dammed and used as reservoirs.

The power utilized on the Rockaway is tabulated beyond. A considerable amount, however, is still unimproved, and all along the Green Pond valley there were once forges, many run by water-power, but most of them not now in operation. At Dover, the Dover Iron Company has a dam 10 feet high and uses a fall of 11 feet, with 100 horse-power during five months, and about 70 all the time by drawing down the pond; at Rockaway a fall of 11 feet and 70 horse-power are used by a rolling-mill; and at Powerville a fall of 10 feet is used for a rolling-mill, forge, and grist-mill, with some 125 horse-power. The principal power on the stream, however, is at Boonton, the total fall in a little over half a mile being about 110 feet. A stone dam at the head of the falls, 150 feet long and 12 feet high, built in 1830, and backing the water only a few hundred feet with an average width of 25 feet, turns the water into a canal on the left bank, from which it was used in four falls; the first was of 25 feet, and was used by a nail factory, with 200 horse-power; the second was of 25 feet, used by a blast-furnace, with 200 horse-power; the third was of 30 feet, used by a rolling-mill, with 500 horse-power; the fourth was of 30 feet, used by a nail factory and saw-mill, with from 60 to 100 horse-power. The Morris and Essex canal, which crosses the river in the pool of the dam, overcomes a difference of level of 80 feet by an inclined plane (No. 7), and uses from the upper canal a fall of perhaps 45 feet and several hundred horse-power to run the machinery for moving the boats, discharging the water so used between the second and third falls. This splendid power was not utilized at the time of my visit, only one steam blast-furnace being in operation. When all the mills were running there was no waste over the dam in the summer, except at night, and steam was used part of the time on the third fall. Full capacity was obtained during about eight or ten months, sometimes falling as low as one-half. The drainage area above this place being about 120 square miles, and the rainfall the same as on the Passaic (see p. 130), I should estimate the minimum flow at about 20 cubic feet per second, and the ordinary low-season flow at about 35 cubic feet per second, corresponding, with a fall of 25 feet, to a gross power of 57 and 100 horse-power, respectively, during twenty-four hours.

The elevation of the top of the canal-plane at Boonton above tide is 480 feet; that of the junction of the Rockaway and the Passaic, some 8 miles below, about 165 feet; so that the fall of the stream in this distance is 315 feet, or at the rate of nearly 40 feet per mile. Of this fall, 110 feet occurs at Boonton, leaving say 200 feet between Boonton and the mouth of the river. There is, no doubt, a very large amount of power available here, very little of which is utilized. At Old Boonton there is a paper-mill, with a fall of 28 feet, the dam having been built in 1880. The power used is stated at 514 horse-power, which can be obtained about seven (?) months. Below Old Boonton the stream is more sluggish and does not afford so much power. When we consider the fact that the facilities for storage are excellent in the valley of the Rockaway, and the large fall available, it would seem that the advantages for power must be excellent, and that the stream is worthy of a careful examination by those seeking good powers. Of the tributaries of the Rockaway, the most important is the Whippany, which affords power for several paper-mills, besides mills of other kinds.

THE WATER-POWER ON THE MORRIS AND ESSEX CANAL.

Before leaving the Passaic river and its tributaries, a few words must be said about the power which is utilized from the Morris and Essex canal, although the amount of power so used is small. The canal, which was completed in August, 1831, and connects the city of Newark with the Delaware river at Phillipsburg, follows the Passaic and Rockaway rivers, rising, by means of 12 inclined planes (with a total rise of 758 feet) and 16 lift-locks (with a total lift of 156 feet), to its summit, near lake Hopatcong, 914 feet above mean tide. West of the summit it follows the Musconetcong valley, descending by 11 planes (with a total fall of 691 feet) and 7 lift-locks (with a total fall of 69 feet) to the Delaware, where it is 154 feet above tide. The canal is fed entirely from lake Hopatcong and from Greenwood lake. The former lake, which originally covered 1,500 acres, is raised 10 feet by a dam, and now covers, when full, 2,800 acres. Its drainage area is 27 square miles. A mill at the outlet owns the right to the original water-power there, so that not all the flow can be used for feeding the canal. As already mentioned, Greenwood lake is raised 13 feet by a dam. There are a number of canal-dams on the rivers which it follows on either side of the summit; none of them are used for feeders, however, but simply in order to enable the canal to cross the river, and the company sees to it that more water is locked into the river than out of it. A number of mills, however, whose works are in some degree interfered with by the canal, receive their regular power from the canal, paying no rent for it. Other mills rent power from the canal, carrying the water around the inclined planes and discharging into the canal below; and finally, the machinery for hauling the boats up the inclined planes is driven by water-power. In cases where the company rents water no special quantity is guaranteed, but the mills have the right to the surplus water only; neither is there any fixed price, and water is sometimes rented in this way for washing and other purposes, instead of for power. In fact, the power available is very limited, and the interests of navigation generally conflict with those of manufacturing. No power is used at the canal-locks. The mills using power are tabulated on page 139, and it is only to be remarked that most of them can obtain their full capacity during only about nine months of the year, and in some cases less.

From the foregoing it is clear that the Passaic river and tributaries offer a large amount of power. The available power, however, could be largely increased by increasing the storage-room, which in many cases could best be done by raising the levels of some of the lakes with which the basin is dotted. Professor Cook gives the following table relating to the ponds and storage:

Reservoirs of the Passaic river.(*a*)

Name of pond.	Tributary to what.	Depth controlled at present.	Area at present.	Pond could be raised—	Area corresponding to pond if raised.	Drainage area.
		Feet.	*Acres.*	*Feet.*	*Acres.*	*Acres.*
Franklin lake	Ramapo river	5	94	0	94	1,000
Rotten pond	....do	[illegible]	20	4	100	1,200
Negro pond	....do	5	100	4	125	900
Truxedo pond, etc	....do	....	....	....	....	....
Mud pond	Ringwood river	4	50	11	120	1,600
Tice's pond	....do	5	40	3	125	800
Shepherd's pond	....do	4	90	6	90	1,000
Greenwood lake	....do	13	2,560	....	....	20,480
Stirling pond	....do	....	....	....	....	....
Macopin pond	Pequannock river	4	362	5	412	3,200
Hank's pond	....do	6	80	5	120	2,500
Cedar pond	....do	4	96	3	140	800
Duck Mountain pond	....do	0	75	12	120	1,600
Dunker pond	....do	5	125	5	800	3,200
Canistear pond	....do	15	70	5	120	2,000
Timber Brook pond	....do	5	72	8	100	800
Stickle's pond	....do	10	101	5	101	1,800
Split Rock pond	Rockaway river	10	237	10	....	4,000
Durham pond	....do	4	65	6	110	1,000
Green pond	....do	0	560	3	....	1,920
Denmark pond	....do	5	175	3	300	1,800
Middle Forge pond	....do	5	70	10	100	4,000
Dixon's Forge pond	....do	5	75	5	....	1,200
Shongum pond	....do	5	125	5	165	1,800

a In addition to these reservoirs, there are the numerous and extensive meadows or swamps, which have already been referred to, and which, although evaporating largely, do something toward regulating the flow.

Professor Cook also gives the following table regarding some sites for artificial reservoirs which could be created:(*a*)

Location.	Tributary to what stream.	Depth which could be rendered available.	Area.	Drainage area.
		Feet.	*Acres.*	*Acres.*
Mouth of Mud pond	Ringwood river	10	100 to 125	3,000
On the Ringwood river	....do	20	570	55,680
Near Hewitt furnace	....do	10	75 to 80	1,300
West of Boardville	....do	10	100 to 150	1,000
Mouth of Stickle's pond	Pequannock river	8	80 to 100	3,000
Mount Pleasant	Rockaway river	10	800	8,320
Pompton Furnace	Ramapo river	6	292	94,720

Besides these, there are various other sites where reservoirs could be created, and there seems to be little doubt that a rainfall of 12 inches, and perhaps more, could be rendered available for almost the whole basin. The upper part of the main Passaic valley, by reason of the flatness of its slope, is unfitted for storage, there being, according to Mr. Croes, only one available site for a reservoir, at Chatham, where a dam 14 feet high above the bed of the stream would flood an area of 2,900 acres, of which 2,600 would be less than 6 feet deep, and nearly all of which is good farming-land. On the Rockaway there is a site for a reservoir 3 miles below Boonton, and others above, so that on this stream the maximum with storage could probably be rendered available.

The only river remaining to be described on the Atlantic coast of New Jersey is the Hackensack. This stream takes its rise in Rockland county, New York, and pursues a southerly course, emptying into Newark bay just above the Passaic. Its fall is small and its flow variable, so that its water-power is of not much importance. It flows for the most part through meadow-lands, and offers no natural falls of any note, so far as could be learned. The power utilized is tabulated beyond.

a *Annual Report of the State Geologist*, 1876.

Drainage areas of the coast streams of New Jersey.

Stream.	Tributary to what.	Locality.	Drainage area.	Remarks.
			Sq. miles.	
Great Egg Harbor river	Atlantic ocean	Mouth	321	Above Great Egg Harbor.
Do	....do	May's Landing	190	
Tuckahoe river	Great Egg Harbor	Mouth	100	According to Professor Cook.
Little Egg Harbor river	Great bay	....do	476	Do.
Wading river	Little Egg Harbor river	....do	179	140 according to Professor Cook.
Do	....do	Harrisville	144	
Batsto river	....do	Mouth	95	70 according to Professor Cook.
Atsion river	....do	Mouth of Batsto river	158	
Cedar creek	Atlantic ocean	Mouth	70	According to Professor Cook.
Tom's river	....do	Tom's River	150	
Metedeconk river	....do	Lakewood	24	
Manasquan river	....do	Mouth	60	Do.
Shrewsbury river	....do	....do	20	Do.
Navesink river	....do	....do	88	Do.
Rahway river	....do	....do	[illegible]	
Raritan river	....do	....do	1,098	1,000 according to Professor Cook.
Do	....do	New Brunswick	852	
Do	....do	Raritan	456	
North branch of Raritan river	Raritan river	Mouth	184	
South branch of Raritan river	....do	....do	270	280 according to Professor Cook.
Do	....do	Clinton	109	
Do	....do	High Bridge	69	
South river	....do	Mouth	122	According to Professor Cook.
Green brook	....do	....do	63	Do.
Stony brook	....do	....do	55	Do.
Millstone river	....do	....do	190	Do.
Lamington river	North branch of Raritan river	....do	100	
Passaic river	Newark bay	....do	962	981 according to Messrs. Croes & Howell.
Do	....do	Passaic	908	
Do	....do	Paterson	813	855.49 according to Messrs. Croes & Howell.
Do	....do	Little Falls	790	750 according to Professor Cook. 832.75 according to Messrs. Croes & Howell.
Do	....do	Mouth of Pompton river	370	
Do	....do	Chatham Bridge	99	105.96 according to Messrs. Croes & Howell.
Do	....do	Millington	51	
Hackensack river	....do	Mouth	199	
Do	....do	Hackensack	130	
Do	....do	Mouth of Pascack creek	56	
Pascack creek	Hackensack river	Mouth	35	
Saddle river	Passaic river	....do	61	
Pompton river	....do	Two Bridges	401	
Pequannock river	....do	Mouth of Ramapo river	204	
Do	....do	Bloomingdale	89.94	According to Messrs. Croes & Howell.
Ramapo river	Pompton river	Mouth	172	168.5 according to Messrs. Croes & Howell. 148 according to Professor Cook.
Do	....do	Pompton Furnace	170	
Do	....do	Ramapo	100	
Ringwood river	....do	Mouth	108	According to Professor Cook. 118.42 according to Messrs. Croes & Howell.
Rockaway river	Passaic river	....do	210	165 according to Professor Cook.
Do	....do	Mouth of Whippany river	138	
Do	....do	Old Boonton	121	
Do	....do	Boonton	120	126.65 according to Messrs. Croes & Howell.
Do	....do	Powerville	118	
Do	....do	Denville	100	According to Professor Cook.
Do	....do	Baker's Forge	30	Do.
Whippany river	Rockaway river	Mouth	71	59 according to Professor Cook.

Table of utilized power on the coast streams of New Jersey.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Great Egg Harbor river	Atlantic ocean	New Jersey	Atlantic	Paper	1	10	80
Do	do	do	do	Cotton	1	11	120
Do	do	do	do	Saw	1	10	42
Tributaries of	Great Egg Harbor river	do	Gloucester	do	1	......	10
Do	do	do	Atlantic	do	1	8	12
Do	Little Egg Harbor river	do	do	do	1	7	24
Do	do	do	Burlington	Flouring and grist	3	24	70
Do	do	do	do	Saw	6	43	101
Do	do	do	do	Paper	1	12	140
Do	do	do	do	Cotton	1	11	130
Do	do	do	Atlantic	Paper	1	11	101
Other tributaries of	Atlantic ocean	do	Cape May	Flouring and grist	4	18	42
Do	do	do	Atlantic	do	4	30	62
Do	do	do	do	Saw	2	12	55
Do	do	do	Ocean	do	13	97	149
Do	do	do	do	Flouring and grist	5	38	90
Do	do	do	do	Box	2	18	27
Do	do	do	do	Flax, hemp, and jute	1	13	32
Raritan river	do	do	Middlesex	Hosiery	1	12	(?)
Do	do	do	Somerset	Flouring and grist	2	28	80
Do	do	do	do	Paint	1	14	15
Do	do	do	do	Machinery	1	14	15
South river and tributaries	Raritan river	do	Middlesex	Flouring and grist	4	38	154
Do	do	do	do	Drugs and chemicals	1	7	90
Do	do	do	do	Shirts	1	16	15
Do	do	do	do	Tobacco	3	39	81
Do	do	do	Monmouth	Flouring and grist	5	56	185
Do	do	do	do	Saw	4	48	49
Lawrence brook	do	do	Middlesex	Flouring and grist	3	37	73
Do	do	do	do	Rubber	1	7	35
Do	do	do	do	Saw	3	32	42
Do	do	do	do	Tobacco	1	7	15
Millstone river	do	do	Mercer	Flouring and grist	1	5	35
Do	do	do	Middlesex	do	2	12	52
Do	do	do	Somerset	do	4	19	258
Tributaries of	Millstone river	do	Mercer	Saw	2	....	20
Do	do	do	do	Flouring and grist	5	42	114
Do	do	do	Monmouth	do	1	16	20
Do	do	do	do	Saw	3	25	51
Do	do	do	Somerset	Flouring and grist	3	23	75
Do	do	do	do	Saw	1	10	10
North branch of	Raritan river	do	Morris	Flouring and grist	2	18	58
Do	do	do	do	Saw	[illegible]	45	53
Do	do	do	Somerset	Flouring and grist	7	72	206
Do	do	do	do	Carriage materials	1	11	12
Do	do	do	do	Saw	2	23	50
Tributaries of	North branch Raritan	do	do	Flouring and grist	6	116	249
Do	do	do	do	Coffins	1	3½	2
Do	do	do	Morris	Flouring and grist	5	87	154
Do	do	do	do	Woolen	1	9	15
Do	do	do	Hunterdon	Agricultural implements	1	14	10
Do	do	do	do	Leather	1	16	10
Do	do	do	do	Saw	2	17	28
Do	do	do	do	Flouring and grist	12	171	221
Do	do	do	Somerset	Saw	1	25	40
South branch of	Raritan river	do	do	Plaster	1	7	15
Do	do	do	do	Saw	3	20	26
Do	do	do	Hunterdon	Looking-glass and picture frames.	1	22	30
Do	do	do	do	Iron castings	1	32	253
Do	do	do	do	Forge	1	12	66
Do	do	do	do	Saw	5	37+	66
Do	do	do	do	Flouring and grist	11	99	365
Do	do	do	Morris	Agricultural implements	1	9	15
Do	do	do	do	Flouring and grist	10	133	341
Do	do	do	do	Saw	10	175	187

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
South branch of	Raritan river	New Jersey	Morris	Wheelwrighting	1	14	12
Tributaries of	South branch Raritan	...do	Somerset	Flouring and grist	4	26	181
Do	...do	...do	Hunterdon	Flax	1	5	8
Do	...do	...do	...do	Linseed oil	1	23	20
Do	...do	...do	...do	Saw	3	25+	68
Do	...do	...do	...do	Flouring and grist	15	283	334
Other tributaries of	Raritan river	...do	Middlesex	...do	4	52+	120
Do	...do	...do	...do	Saw	1	6	16
Do	...do	...do	...do	Shirts	1	11	16
Do	...do	...do	...do	Marble and stone work	1	....	3
Do	...do	...do	...do	Printing and publishing	1	....	2
Do	...do	...do	...do	Slaughtering	2	....	10
Do	...do	...do	Union	Flouring and grist	2	28	65
Do	...do	...do	...do	Paper	1	38	44
Do	...do	...do	Somerset	Flouring and grist	3	44	54
Do	...do	...do	...do	Fur-dressing	1	22	53
Do	...do	...do	...do	Saw	1	8	15
Do	Atlantic ocean	...do	Monmouth	Flouring and grist	19	209	474
Do	...do	...do	...do	Carriages	1	8	16
Do	...do	...do	...do	Saw	13	120	198
Do	...do	...do	Middlesex	Flouring and grist	1	9	30
Passaic river	Newark bay	...do	Somerset	...do	1	20	30
Do	...do	...do	...do	Saw	1	8	24
Do	...do	...do	Union	Wheelwrighting	1	9	20
Do	...do	...do	Morris	Flouring and grist	2	16	216
Do	...do	...do	...do	Saw	3	37	64
Do	...do	...do	...do	Paper	1	7½	110
Do	...do	...do	Passaic	Flouring and grist	2	21	62
Do	...do	...do	...do	Bagging, flax, hemp, and jute	1	21	125
Do	...do	...do	...do	Machinery	8	128+	508
Do	...do	...do	...do	Paper	1	22	250
Do	...do	...do	...do	Printers' fixtures	1	3½	12
Do	...do	...do	...do	Printing and publishing	1	....	2
Do	...do	...do	...do	Shoddy	1	3	40
Do	...do	...do	...do	Thread linen	1	....	180
Do	...do	...do	...do	Vulcanized rubber	1	22	148
Do	...do	...do		Wire	1	....	6
Do	...do	...do	...do	Wood-turning	1	....	6
Do	...do	...do	...do	Woolen	3	62	430
Do	...do	...do	...do	Cotton	2	....	660
Do	...do	...do	...do	Carpet and felt	1	16	250
Do	...do	...do	...do	Silk	8	176	619
Saddle river	Passaic river	...do	Bergen	Flouring and grist	6	41	81
Do	...do	...do	...do	Saw	4	27	127
Do	...do	...do	...do	Agricultural implements	1	[illegible]	8
Do	...do	...do	...do	Bleaching and dyeing	1	7½	30
Do	...do	...do	...do	Edge-tools	1	6	8
Do	...do	...do	...do	Hosiery	1	8	12
Ramapo river	Pompton river	...do	Passaic	Steel-works	1	20-24	200
Do	...do	...do	Bergen	Flouring and grist	1	6	18
Do	...do	...do	...do	Saw	4	24	47
Do	...do	...do	...do	Electrotyping	1	5	20
Do	...do	...do	...do	Bronze foundery	1	4	12
Do	...do	New York	Orange	Flouring and grist	4	61	102
Do	...do	...do	...do	Blast-furnace	1	12	150
Do	...do	...do	Rockland	Shoddy	1	12	32
Ringwood river and tributaries	...do	New Jersey	Passaic	Bobbins	1	3½	13
Do	...do	...do	...do	Blast-furnace	1	14	75
Do	...do	...do	...do	Flouring and grist	4	42	63
Pequannock river	...do	...do	Morris	Bark	1	9	12
Do	...do	...do	...do	Flouring and grist	1	7	10
Do	...do	...do	...do	Saw	2	23	23
Do	...do	...do	...do	Rubber	2	44	340
Do	...do	...do	...do	Paper	2	30	207
Do	...do	...do	Passaic	Flouring and grist	3	26	59
Do	...do	...do	...do	Blomary and forge	1	15	30

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Rockaway river	Passaic river	New Jersey	Morris	Cutlery	1	8	*a* 8
Do	do	do	do	Flouring and grist	6	63	119
Do	do	do	do	Saw	1	14	*a* 20
Do	do	do	do	Rubber	1	18	*a* 45
Do	do	do	do	Rolling-mills	2	20	195
Do	do	do	do	Rolling-mill, etc	1	110	*b* 1,000
Do	do	do	do	Blast-furnace	1	24	250
Do	do	do	do	Blomaries and forges	3	31	151
Other tributaries of	do	do	do	Baskets, etc	1	30	8
Do	do	do	do	Foundery facings	1	11	15
Do	do	do	do	Flouring and grist	11	201	332
Do	do	do	do	Saw	3	45	49
Do	do	do	do	Paper	4	80	165
Do	do	do	do	Blomary and forge	1	80	45
Do	do	do	do	Cotton	1	....	50
Do	do	do	do	Woolen	1	24	15
Do	do	do	Passaic	Flouring and grist	1	19	40
Do	do	do	do	Paper	1	18	50
Do	do	do	do	Carriage and wagon materials.	1	12	20
Do	do	do	do	Screws	1	7	8
Do	do	do	do	Toys and games	1	7	3
Do	do	do	do	Wood-turning	1	8	18
Do	do	do	Somerset	Carriage and wagon materials.	1	14	6
Do	do	do	Sussex	Leather	1	8	8
Do	do	do	Essex	Carpentering	1	....	2
Do	do	do	do	Jewelry	1	....	1
Do	do	do	do	Printing and publishing	1	....	1
Do	do	do	do	Sewing-machines	1	13	*a* 25
Do	do	do	do	Paper boxes	1	10	16
Do	do	do	do	Bronze-powder	2	55	53
Do	do	do	do	Carriage and wagon materials	1	20	30
Do	do	do	do	Copper-rolling	1	18	100
Do	do	do	do	Foundery facings	1	18	18
Do	do	do	do	Flouring and grist	2	49	*a* 125
Do	do	do	do	do	5	109	115
Do	do	do	do	Machine-shop	1	20	*a* 30
Do	do	do	do	Cotton	1	16	15
Do	do	do	do	Woolen	3	31	119
Do	do	do	do	Saw	4	75	65
Do	do	do	do	Paper	1	32	*a* 130
Do	do	do	do	do	1	11	60
Do	do	do	do	Wire	1	15	60
Do	do	do	do	Wood-turning	1	18	7
Do	do	do	Bergen	Woolen	2	28	40
Do	do	do	do	Cotton	3	64	125
Do	do	do	do	Flouring and grist	9	125	97
Do	do	do	do	Saw	6	65	70
Do	do	do	do	Bark	1	10	25
Do	do	do	do	Wood-turning	1	14	30
Do	do	do	do	Paper	1	13	59
Do	do	do	do	Vulcanized rubber	1	14	25
Do	do	New York	Orange	Flouring and grist	1	24	25
Do	do	do	Rockland	Agricultural implements	1	[illegible]	5
Do	do	do	do	Flouring and grist	6	59+	110
Do	do	do	do	Saw	3	42	129
Do	do	do	do	Leather	1	11	4
Do	do	do	do	Foundery	1	20	15
Hackensack river	Newark bay	New Jersey	Bergen	Flouring and grist	2	16	35
Do	do	do	do	Saw	1	5	40
Do	do	do	do	Furniture	1	5	20
Do	do	New York	Rockland	Flouring and grist	1	15	80
Tributaries of	Hackensack river	New Jersey	Bergen	do	6	63	98
Do	do	do	do	Saw	5	47	108

a From Morris and Essex canal. *b* Not in operation since July 1, 1876.

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Hackensack river	New Jersey	Bergen	Furniture	1	6	7
Do	do	do	do	Wood-bending	1	10	10
Do	do	do	do	Leather	1	6	25
Do	do	New York	Rockland	Flouring and grist	8	113	192
Do	do	do	do	Saw	4	45	47
Do	do	do	do	Woolen	1	....	10
Other tributaries of	Atlantic ocean	New Jersey	Marion	Flouring and grist	7	75+	183
Do	do	do	do	Paper	2	32	80
Do	do	do	do	Printing and publishing	1	....	3
Do	do	do	Essex	Flouring and grist	2	35	70
Do	do	do	do	Paper	6	130	230

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REPORT ON THE WATER-POWER

OF THE

SOUTHERN ATLANTIC WATER-SHED,

BY

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SPECIAL AGENT.

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REPORT ON THE SOUTHERN ATLANTIC WATER-SHED.

PREFATORY LETTER.

BOSTON, MASS., *September* 20, 1881.

Prof. W. P. TROWBRIDGE,
Columbia College, New York City.

SIR: I have the honor to submit herewith my report on the water-power of the streams draining what I have designated as the "Southern Atlantic Water-shed", or, in other words, of the streams flowing into the Atlantic south of the James river. My report on the streams of the middle Atlantic water-shed, comprising the streams as far north as the Hudson, is in course of preparation, and will be duly submitted when completed. In making this division of the territory assigned me I have been guided by a desire to group together such streams as possess the greatest number of features in common, and it seemed as though the line had best be drawn at about the southern limit of the state of Virginia, which is often classed as one of the middle states.

Following the directions which I have from time to time received from you, I have traveled over most of the country covered by this report, and have collected as much information as was possible with the time at disposal. With so large a territory to traverse in so short a time, anything like thoroughness has, of course, been impossible, and my work must be considered a rough reconnoissance only. I have been able to visit in person only a few of the water-powers in my district, many of which are inaccessible; and, for information regarding even some of the important ones, I have been obliged to depend on hearsay or on correspondence. Even in the case of powers which I visited I am able, in many cases, to present only their general features, having been unable to spare the time necessary for a detailed examination. The only instrument of measurement used was a Locke pocket-level, with which I was enabled to arrive, in some cases, at quite close approximations to the fall, while in others the results obtained are liable to large error. Those who have used the instrument will testify to the fact that, when long sights have to be taken, the want of sensitiveness of the bubble renders accurate results impossible. In one case I was enabled to make use of an aneroid barometer, kindly loaned me for the occasion by Professor Kerr, the state geologist of North Carolina, but with this single exception the pocket-level was the only instrument of measurement used.

In preparing this report I have made use of all the material within my reach, giving due acknowledgment in each case where other reports or publications have been used extensively. To the reports of the Chief of Engineers, U. S. A., and those of the officers of the corps, I am indebted for so much information that it would be useless to attempt to refer to the authority for each statement taken from them, when it is not of particular importance. To the officers themselves, and their assistants, I am also personally indebted for valuable aid, advice, and information while at work in the field. My acknowledgments are also due in this place to the officers and engineers of the various railroads in the district, who have, with the greatest kindness and interest, furnished me with elevations of streams along their roads, and with general information concerning the country. To civil engineers, state officers, and private citizens, all through the district, I am indebted for the greatest encouragement in the prosecution of my work, and for information of all kinds. Particularly must I here acknowledge the obligations I am under to Prof. W. C. Kerr, state geologist of North Carolina, for copies of reports on geology and allied subjects bearing on water-power, and for aid and advice in very many cases. To him is due chiefly whatever success may be found to have attended my efforts to present an adequate view of the water-power of his state.

In discussing the material thus collected I have, after dividing my district into the two divisions above named, prefaced the descriptions of the various rivers by a general description of the districts so far as their common characteristics are concerned. In giving information regarding particular powers I have endeavored to let each statement pass for what it is worth, and for no more; and where inaccuracies are liable to occur, I have repeatedly called attention to them.

The drainage areas given in the report were measured geometrically, there being no planimeter in possession of the office at the time they were determined. I have, however, checked them in so many ways that I believe them to be accurate measurements of the areas as taken from the maps. The latter are, in many cases, so inaccurate that slight errors in measurement are of no importance. I have uniformly used Colton's largest maps of the separate states, which were the best I could find. In checking my measurements of the drainage-basins of the larger streams, by comparing them with those of Mr. Gannett, published in Census Bulletin No. 78, I have had the satisfaction of finding that the two agree, generally, within 1 or 2 per cent.

In making estimates of the amount of power available at the various sites I have endeavored to proceed according to the most approved methods in use in this country, and to pay proper attention to the most advanced and recent investigations in this direction. Having fully explained, in the introduction, the methods I have used, it is unnecessary for me to do more here than to call attention to this point. In view of the uncertainty attending all such estimates of power, in the absence of a series of gaugings of the streams in question, it may seem that I have gone too far in this direction; but it has appeared to me that it was essential to give some idea of the amount of power which could be fairly expected at each important site, in order that people might not be misled by too high estimates, which are the rule and not the exception.

Finally, regarding the arrangement of this report, it is to be remarked that, although a logical arrangement would probably have placed this report on the southern Atlantic water-shed after that on the middle Atlantic water-shed, various causes have combined to render it advisable to prepare and submit the present report first; among which may be mentioned the completeness of the data at hand, and the fact that I consider this report, on the whole, the more important of the two. It is hoped that this sacrifice of logical sequence will not involve any loss of clearness.

I am, sir, very respectfully, your obedient servant,

GEORGE F. SWAIN,
Special Agent.

THE SOUTHERN ATLANTIC WATER-SHED.

Having divided the territory covered by my examination into two districts, the middle and the southern Atlantic water-sheds (the boundary between the two being the ridge between the basins of the James river and the streams south), I proceed first to discuss the second of these districts.

The state of Florida will for the present be left out of consideration, partly because it possesses no water-power of importance, and partly because its peculiar situation renders its climate, in some respects, different from that of the other southern Atlantic states. The few remarks that are to be made regarding Florida will be found at the end of this report.

The general characteristics of the territory considered will first be given, and afterward a discussion of each stream separately.

GENERAL CHARACTERISTICS.

1.—Area and form.

The area to be considered comprises about 117,350 square miles, distributed, approximately, as follows among the different states:

	Square miles
Virginia	10,350
North Carolina	45,000
South Carolina	31,000
Georgia	31,000
Total	117,350

This area is in the shape of a strip lying along the Atlantic ocean between the parallels of (nearly) 30½° and 36½° north latitude, and with an average breadth, at right angles to the coast, of about 240 miles, except in the extreme southern part, where it narrows down to about 60 miles. The general direction of the coast-line is northeast and southwest, turning quite abruptly to the north in North Carolina, and curving toward the south in Georgia.

2.—Geographical and continental position.

The district considered is therefore in the north temperate zone, and in the zone in which the prevailing winds are the return trades, which blow from the southwest. The winds are, however, not constant, but blow from all points of the compass, and the prevailing ones from different points, according to the season. I shall discuss the winds more fully under the head of "climate", and it will suffice to say here that, in consequence of the continental position of the region considered—extending almost to the Gulf of Mexico, and flanked on the west by the system of the Alleghanies—the winds from all points of the compass, from northeast, through east and south, to southwest, are, to a certain degree, oceanic, varying in different parts of the region, while the distinctly land-winds are those from the west, northwest, and north. This district is, in fact, directly in the line of the return trades, which blow from the Gulf of Mexico, carrying its vapors far inland, and far along the coast, even so far as Virginia, the influence of the Gulf being, as regards moisture and rain-fall, much more sensible than that of the Atlantic ocean as regards the region as a whole.

3.—Topography.

The district under consideration may be divided, topographically, into three distinct and well-defined divisions, viz, the lower or eastern, the middle, and the mountainous or western.

The *eastern division* extends from the coast inland for a distance varying between 100 and 140 miles, and including the navigable portions of the rivers. Its boundary inland is a line passing through Richmond and Petersburg, Virginia; Weldon, Rocky Mount, Smithfield, North Carolina; a little above Fayetteville, North Carolina, Cheraw and Camden, South Carolina; and through Columbia, South Carolina, and Augusta, Milledgeville, Macon, and Columbus, Georgia. This line plays a very important part in the topography, geology, and water-power of the country, and is nothing more than the continuation of the line which may be designated as the *fall-line*, and which extends through the middle states, passing through Fredericksburg and Georgetown. It may be traced beyond Columbus for some distance along the Gulf, passing through Wetumpka and Tuscaloosa, Alabama. In the northern part of this district tide-water extends up to the fall-line, as at Richmond and Petersburg, but in the southern part the line is a long distance above tide-water. In another place I shall refer to this line and the important water-powers connected with it. The country between it and the coast belongs, geologically, to the Tertiary and Post-tertiary formations, and "is for the most part nearly level or very gently undulating, except along the river courses, on the upper reaches of which rise bluffs and small hills".* It comprises nearly two-fifths of the area of North Carolina,† over one-half of that of South Carolina, and about two-thirds of that part of Georgia which we are considering. Its slope seaward in North Carolina is between one and two feet to the mile,* and is probably about the same in South Carolina and Georgia. Its average elevation above the sea is probably in the neighborhood of 150 or 175 feet, and the slope toward the sea is, on the whole, uniform.

The rivers in this division are sluggish and navigable streams, frequently tidal for 20 or 30 miles from their mouths, and flow in beds composed of sand and clay. They are often exceedingly tortuous, and the chief obstructions to navigation consist in shifting sand-bars, snags, and trees, which have been undermined and have fallen over into the stream. The banks are unstable, and although the rivers do not rise very high in freshets in this part of their course, they frequently undermine the banks, and even cut new channels for themselves, in consequence of their extreme tortuosity, although they are not so crooked as many of the western streams. We shall notice, farther on, the bearing of these facts on the availability or accessibility of the water-powers.

The river valleys in this division are characterized by having their longest slopes on the north side of the river, from which side also the principal tributaries enter—facts which have been clearly explained by Professor Kerr.

The *middle division*, or hill country, extends from the fall-line to the base of the mountains, with an average width of from about 100 or 120 miles in the south to 150 in the north. It includes nearly one-half of North Carolina, nearly one-half of South Carolina, and about one-third of that part of Georgia which we are considering. Its boundaries are, topographically, not very sharply defined, and it forms a term of transition from the sea-board plane to the mountains. Geologically, almost the entire region is metamorphic.

The average elevation above the sea of the streams at the fall-line is probably not far from 125 feet, varying from about 250 feet in the south to about 50 feet in the north. The following list of elevations of streams will show how the elevation varies between Richmond, Virginia, and Macon, Georgia. I am indebted for the figures to various railroad managers and engineers, and to other sources: ‡

River.	Place.	Elevation above mean tide.
		Feet.
James	Richmond, Va	‡0.0
Appomattox	Petersburg, Va	‡0.0
Roanoke	Weldon, N. C	44.0
Tar	Rocky Mount, N. C	....
Neuse	Smithfield, N. C	100.0
Cape Fear	Averysboro', N. C	35.0
Pee Dee	C. C. R. R. crossing	106.0
Wateree	10 miles above Camden	125.0
Congaree	Columbia, S. C	129.0
Savannah	Augusta, Ga	125.0
Ogeechee	Shoals of Ogeechee, 8½ miles below Mayfield, Ga	210.0
Oconee	Milledgeville, Ga	220.0
Ocmulgee	Macon, Ga	250.0

The average elevation of the ground along the fall-line is greater, probably averaging 200 feet, varying from 300 feet in Georgia to 100 feet in Virginia and northern North Carolina. The average elevation of the upper limit of the middle division may be taken at about 1,200 feet, and the average elevation of the whole district at about

* *Geology of North Carolina*, vol. i, W. C. KERR.

† Prof. KERR, *Geology of North Carolina.*

‡ This table is only a rough approximation. It was not possible to get accurate elevations on account of differences in the datum-planes used by the various railroad companies. For instance, Richmond and Petersburg are at the heads of tide-water; yet the rivers there are probably several feet above mean tide at Norfolk. In some cases the above figures have been obtained by estimating the fall above points whose elevations were given.

700 feet. Its average slope is, therefore, not less than 5 or 6 feet to the mile. The character of this division varies by insensible degrees from that of the flat eastern division to that of the mountainous western one. The eastern part is gently rolling, while the western is penetrated by numerous spurs of the mountains, forming divides between the great river-basins, and sometimes with elevations exceeding 3,000 feet.

The rivers in this region are tolerably rapid, and well suited for the development of water-power. They are not navigable, on account of the numerous shoals and ledges, though some of them might be made so. Almost all of the water-power now used is in this section.

The *western* or *mountainous division* comprises the Atlantic slope of the Blue Ridge, and occupies but a small part of the area under consideration. The general direction of the Blue Ridge is about NE., a little E., nearly parallel to the coast, and it is in North Carolina that the system to which it belongs attains its greatest altitude, some of the peaks attaining an elevation of over 6,000 feet, while some peaks in Georgia exceed 4,000 feet in height. Although the chain of the Blue Ridge is far from regular, either in direction or in elevation, contrasting strongly in these respects with the Smoky mountains, a second range lying west of it, yet the general structure of these mountains is the same as in the middle states; they consist of a series of ridges, and not, like the mountains of Maine, of a series of isolated cones.

The streams in this division are, of course, small and very rapid. Their fall is very great, and is interrupted in many cases by cascades and precipitous falls, sometimes of several hundred feet, nearly vertical. The bed is almost always rock, sometimes overlaid with a stratum of gravel, and the valleys narrow, in some places with very steep and even vertical banks—hundreds of feet high in a few very rare cases. These streams are subject to considerable fluctuations in volume, and the water-power, although great, is not very available.

There are no lakes in any part of the region under consideration except a few near the coast, a position which renders them of no value as regards water-power.

4.—Geology, soils, and forests.

As has been already stated, the entire eastern division of this district belongs to the Tertiary and Quaternary formations. Its soil is for the most part a sandy loam. Clay and sand, in fact, constitute the soil of almost the whole district; in the eastern part the sand predominates, while in the middle and western parts the clay predominates. There are also in the eastern part beds of gravel, marl, and peat, and there is generally a clay subsoil not far below the surface. In some places, too, there are beds of quite pure sand (the sand-hills), which give rise to several streams noticeable for their water-power, and there seems to be a belt of these sand-hills just below the fall-line, having a width of 30 to 40 miles in places.

In the middle and western parts of the region, besides the clay soil just referred to, and which is the predominant soil, there are also beds of gravel and sand. It is an important fact that the soil here is very deep—much deeper than in the middle states—and that it has resulted from the decay of the rocks *in situ*. The clay is generally red, less frequently yellow, and, being mixed to a considerable extent with sand and gravel, it is not impervious. When well compacted, however, it is said to make a good dam.

Almost all of the middle and western parts of this region are metamorphic. The general direction of the strike of the strata is NE. and SW., about parallel to the mountains, and the streams cross these strata generally at large angles, and thus form shoals, which afford abundance of fine water-power. The prevailing rocks are granite and gneiss, with their varieties. In upper South Carolina nearly all the water-powers are caused by the streams crossing the ledges of gneiss, and the same is true for the other states, though, perhaps, not to so great a degree. It is important to notice that the rocks are generally impervious.

On account of the important influence exercised by forests on water-power, it is an important fact that the greater part of the region we are considering is well wooded. The eastern part abounds in extensive forests of long-leaf pine, with large quantities of cypress and palmetto along the river-bottoms, but in the middle portion there is, unfortunately, no effort made to preserve the forests, and they are said to be disappearing rapidly. In the western part they are abundant, the mountains being heavily wooded. Some of the peaks, however, called *balds*, are, it is true, entirely destitute of trees on their summits, but in general the mountains are covered with heavy forests. It is important to notice, also, that the mountains, even the highest ranges and peaks, are covered with soil to a considerable depth.

As regards variety of woods, it is sufficient to mention the fact that the state of Georgia alone produces 230 different kinds of wood.*

* Dr. Little, in *Eclectic Geography*, Georgia edition.

According to the census of 1870 the number of square miles of land not in farms, added to that of woodland in farms, is as follows for the different states:

State.	Land area of state.	Area above described.	Per cent.
Virginia	40, 125	24, 733	61
North Carolina	48, 580	36, 379	75
South Carolina	30, 170	21, 324	71
Georgia	58, 980	42, 230	72
Maine	29, 895	24, 249	81
New Hampshire	9, 005	5, 007	56
Vermont	9, 135	4, 226	46
Massachusetts	8, 040	4, 878	61
Rhode Island	1, 085	565	52
Connecticut	4, 845	2, 053	42
New York	47, 620	21, 822	46
New Jersey	7, 455	3, 906	52
Pennsylvania	44, 985	25, 839	57
Maryland	9, 860	5, 053	51

How much of the areas in the second column are woodlands I cannot say. It seems probable, however, that the southern states are better wooded than the New England and middle states, except Maine.

5.—Climate.

The climate exercises such an important influence on the water-power of a district that it seems necessary to consider it in some detail. The following elements, which go to determine the climate of a place, will be considered: *a.* Length of coast and character of ocean-currents; *b.* prevailing winds at different seasons; *c.* temperature at different seasons; *d.* precipitation, amount in different seasons and distribution over the area considered; *e.* evaporation and moisture.

a. Coast-line and ocean-currents.—The fact has been already referred to that the general direction of the coast-line is NE. and SW., and that the winds from NE. round to SW. are maritime. The total length of coast-line, not including indentations, is in the neighborhood of 580 miles. Along this coast, and a short distance from it, sweeps the Gulf Stream, keeping its course across the Atlantic from cape Hatteras, and leaving the upper part of North Carolina and the states north exposed in a greater degree to the cold current from the north, which flows along the New England coast. Hence, the winds from NE. are cool, while those from SE. are warm and moist. The effect of all these circumstances on water-power will be referred to again.

b. Prevailing winds at different seasons.—The winds in this district are variable. They blow from all quarters, the prevailing wind being different in different parts of the region, and at different seasons. On the whole, however, the prevailing winds are from the west, or some point between SW. and NW. But it is a very striking fact that the resultant wind, or the wind found by working out a traverse from observations of the frequency of the various winds throughout the year,* is almost invariably, in all parts of the region, from a point between SW. and NW., a fact which indicates that the general movement of the atmosphere is toward the east. On the immediate seaboard the winds from S. and SE. are frequent, and in the middle section northerly winds are, at least in North Carolina, very frequent, coming next in order to those from the west. As regards the distribution of the winds through the seasons, the winds from S., SE., and SW. are most prominent during the spring and summer, while in autumn and winter the winds from N., NE., and NW. are most frequent. Winds from the east are the least frequent of all.

As regards water-power, the most salient points to be noticed are that there is no distinct periodicity in the winds, and that the general movement of the atmosphere in summer and spring is from a point south of west, and in autumn and winter from a point north of west.

c. Temperature at different seasons.—The mean temperatures for the year and for the seasons, as well as the extremes and the range, vary considerably in the three divisions of the region we are considering. In fact, the isothermal lines, instead of following the parallels of latitude (their normal course), are deflected toward the south by the mountains which bound the district on the west, and in the western division they run almost parallel to the coast, while in the middle and eastern divisions they run at an angle of some 45° with it. The following tables, consisting of observations selected from among those given in the *Smithsonian Contributions to Knowledge*, vol. 21, and in Professor Kerr's report on the geology of North Carolina, will give some idea of the temperature in different parts of the region, and at different seasons. The means for the different sections have been obtained by examining the temperature charts in the publications of the Smithsonian Institution.

* Coffin: *The Winds of the Globe.*—Smithsonian Contrib., vol. 20.

Observations of temperature at different seasons.

Division.	Station.	Latitude.	Longitude.	Elevation.	Mean temperature (degrees Fahrenheit). Spring.	Summer.	Autumn.	Winter.	Year.	Length of time observed.
		° ′	° ′	Feet.						Yr. mo.
Eastern	Norfolk, Va	36 51	76 17	20	57	77	61	42	59	25 0
	Murfreesboro', N. C	36 26	77 01	75	58	76	59	43	59	4 0
	Weldon, N. C	36 23	77 45	72	57	78	56	40	58	3 0
	Poplar Branch, N. C	36 14	76 00	10	57	79	62	43	60	2 0
	Scotland Neck, N. C	36 07	77 32	50	56	75	57	41	57	2 0
	Goldsboro', N. C	35 21	78 02	102	61	80	62	45	62	4 0
	Wilmington, N. C	34 17	77 58	50	62	79	63	48	63	3 0
	Aiken, S. C	33 32	81 33	565	61	77	62	46	62	8 8
	Camden, S. C	34 15	80 31	240	62	79	62	45	62	9 9
	Charleston, S. C	32 47	79 56	20	65	80	67	51	66	44 8
	Fort Moultrie, S. C	32 45	79 51	25	66	81	68	52	67	32 11
	Perry, Ga	32 28	83 43	280	67	80	65	49	65	2 3
	Savannah, Ga	32 05	81 06	42	67	81	67	53	67	26 1
Middle	Lynchburg, Va	37 22	79 12	800	55	75	58	40	57	3 9
	Gaston, N. C	36 28	77 38	152	56	76	58	40	58	4 6
	Oxford, N. C	36 22	78 29	475	57	78	58	40	58	7 0
	Greensboro', N. C	36 05	79 50	843	60	78	62	41	60	3 0
	Chapel Hill, N. C	35 58	78 54	570	59	76	61	42	60	20 0
	Lenoir, N. C	35 57	81 34	1, 185	55	74	55	38	56	3 0
	Statesville, N. C	35 47	80 53	940	53	74	54	36	54	7 0
	Raleigh, N. C	35 47	78 41	350	58	78	60	40	59	4 0
	Charlotte, N. C	35 16	80 50	725	59	77	58	40	59	3 0
	Albemarle, N. C	35 18	80 11	650	56	77	57	40	58	4 0
	Abbeville, S. C	34 12	82 17	500	63	79	63	47	63	2 10
	Columbia, S. C	34 02	80 57	315	62	78	63	45	62	4 11
	Athens, Ga	33 58	83 25	850	61	76	61	46	61	6 6
	Atlanta, Ga	33 45	84 24	1, 050	58	75	58	42	58	5 2
	Penfield, Ga	33 38	83 09	724	60	79	61	45	61	2 7
	Augusta Arsenal, Ga	33 28	81 53	350	64	80	64	48	64	21 7
	Sparta, Ga	33 15	82 54	550	62	78	63	46	62	9 0
Western	Boone, N. C	36 14	81 39	3, 250	47	68	48	32	49	2 0
	Bakersville, N. C	36 03	82 06	2, 550	51	71	52	36	53	1 0
	Asheville, N. C	35 36	82 28	2, 250	53	72	54	38	54	6 6
	Murphy, N. C	35 06	83 29	1, 614	56	72	53	39	55	2 6
	Clarksville, Ga	34 40	83 31	1, 632	....	72	56	44	....	2 3
	Brunswick, Me	43 54	69 57	74	42	65	48	23	45	51 3
	Concord, N. H	43 12	71 29	374	44	68	49	23	46	22 2
	Boston, Mass	42 21	71 03	82	46	69	51	28	49	38 5
	Providence, R. I	41 50	71 24	155	45	68	51	27	48	34 8
	Hartford, Conn	41 46	72 41	60	48	70	52	30	50	16 6
	New Haven, Conn	41 18	72 57	45	47	70	51	28	49	86 0
	Albany, N. Y	42 39	73 44	130	47	70	50	25	48	45 11
	New York, N. Y	40 45	73 58	42	48	73	55	31	52	21 11
	Newark, N. J	40 44	74 10	35	48	70	53	31	51	24 5
	Reading, Pa	40 20	75 55	269	50	72	53	31	52	6 8
	Harrisburg, Pa	40 16	76 53	375	52	76	55	32	54	29 3
	Philadelphia, Pa	39 56	75 10	36	51	74	54	33	53	39 10
	Carlisle Barracks, Pa	40 12	77 11	600	50	73	52	30	51	29 5
	Fort Delaware, Del	39 25	75 34	10	52	75	58	34	55	18 10
	Baltimore, Md	39 17	76 37	80	52	73	55	34	54	18 9
	Washington, D. C	38 54	77 02	75	56	76	56	30	56	12 3
	Cincinnati, Ohio	39 06	84 30	540	54	75	55	34	55	36 8
	Chicago, Ill	41 54	87 38	600	44	67	48	25	46	17 3
	Peoria, Ill	40 43	89 30	512	51	74	53	27	51	14 9
	Fort Madison, Iowa	40 37	91 28	600	50	75	52	25	51	21 10
	Muscatine, Iowa	41 26	91 05	586	47	69	49	23	47	27 6
	Huntsville, Ala	34 45	86 40	600	60	76	60	42	60	13 0
	Mobile, Ala	30 41	88 02	15	67	79	66	52	66	10 0
		Deg.								
Eastern	North Carolina and Virginia	34.5 36.5	....	0 200	59	79	60	40	61	......
	South Carolina	32.5 34.5	....	0 300	62	79	63	48	63	......
	Georgia	31.0 33.0	....	0 350	67	80	64	50	65	......
	Total	31.0 36.5	....	....	62	79	63	48	63	......

Observations of temperature—Continued.

Division.	Station.	Latitude.	Longitude.	Elevation.	Mean temperature (degrees Fahrenheit).					Length of time observed.
					Spring.	Summer.	Autumn.	Winter.	Year.	
		Deg.	*Deg.*	*Feet.*						*Yr. mo.*
Middle	North Carolina and Virginia	37.0 35.0		200 1,200	57.00	77.00	59.00	44.00	59.00	
	South Carolina	35.0 34.0		300 1,100	61.00	77.00	62.00	45.00	61.00	
	Georgia	34.5 32.5		350 1,100	60.00	77.00	61.00	44.00	60.00	
	Total	37.0 32.5			60.00	77.00	61.00	44.00	60.00	
Western	North Carolina and Virginia	37.0 35.0		1,200 6,000	52.00	70.00	52.00	36.00	52.00	
	South Carolina									
	Georgia	35.0 34.0		1,100 4,000	54.00	72.00	55.00	36.00	54.00	
	Total	37.0 34.0			53.00	71.00	54.00	36.00	53.00	
	New England	42.5 41.0			46.00	69.00	51.00	28.00	49.00	
	New England	44.0 42.5			43.00	67.00	49.00	23.00	45.00	
	Middle States	41.0 39.0			50.00	73.00	54.00	32.00	52.00	
	Western States	41.5 39.0	91.5 84.5		49.00	72.00	51.00	26.00	50.00	

For comparison, the results are tabulated for some places in other parts of the United States at the end of the table. The places named as belonging to the western division are really outside of it, on the other side of the Blue Ridge; but as no records of observations for places on this side of the ridge could be found, I have inserted these values, as giving an idea of the temperature in that region, which may be considered accurate enough. The averages for the three divisions, at the end of the table, as well as for the other parts of the country, are only approximations, but are close enough to give a general idea of the differences between the region we are considering and the other parts of the country.

These tables show that middle South Carolina is somewhat warmer than middle Georgia, and much warmer than middle North Carolina. The isothermals bend inward, or around South Carolina, receding further from the coast in that state than in North Carolina or Georgia.

The following table of extreme observed temperatures may be interesting:

State.	Maximum temperature observed.	Month.	Place of observation.	Minimum temperature observed.	Month.	Place of observation.
	Deg.			*Deg.*		
North Carolina	102	July	Fort Johnston	3	February	Fort Johnston.
South Carolina	101	July	Charleston	[illegible]	February	Fort Moultrie.
Georgia	103	July	Augusta arsenal	—2	February	Augusta arsenal.
Alabama	104	August	Mount Vernon arsenal	—9	January	Huntsville.
Maine	102	July	Brunswick	—32	January	Brunswick.
Massachusetts	100	July	Fort Warren	—30	January	Williamstown.
Virginia	104	August	Alexandria	2	January	Fort Monroe.

These figures, as well as all the others pertaining to temperature and rainfall, have been taken principally from the *Smithsonian Contributions.* Lorin Blodgett, in his *Climatology of the United States*, p. 150, gives figures somewhat different. Thus, he states that in the winter of 1834 and 1835, which was a winter of extreme cold in the south, the temperature at several places was as follows: On January 4, at Alexandria, Virginia, —16°; in February, at Richmond, —6°; Norfolk, +4°; Fayetteville, North Carolina, —1°; Greenville, South Carolina, —11°; Athens, Georgia, —10½°; Clarksville, Georgia, —15°; Milledgeville, Georgia, —9°; Augusta, Georgia, —2°.

The following table gives the average temperature of the warmest day and the coldest day of the year, calculated, by Bessel's formula, from the recorded observations:

Place.	Latitude.	Longitude.	Elevation.	Temperature of warmest day.	Temperature of coldest day.	Range.	Number of years of observations.
	° ′	° ′	*Feet.*	*Deg.*	*Deg.*	*Deg.*	*Yrs. mo.*
Fort Brady, Mich	46 30	84 28	600	65.2	14.4	50.8	32 1
Brunswick, Me	43 54	69 57	74	67.9	19.5	48.4	51 3
New Bedford, Mass	41 39	70 56	90	70.2	27.1	43.1	58 1
New Haven, Conn	41 18	72 57	45	72.4	25.7	46.7	86 0
Baltimore, Md	39 16	76 35	36	77.0	32.0	45.0	36 0
Cincinnati, Ohio	39 06	84 30	540	77.9	32.3	45.6	36 8
St. Louis, Mo	38 37	90 12	481	78.5	30.3	48.2	41 0
Chapel Hill, N. C	35 58	78 54	570	78.9	40.9	38.0	20 0
Fort Moultrie, S. C	32 45	79 51	25	82.2	50.1	32.1	32 11
Fort Barrancas, Pensacola, Fla	30 21	87 18	20	82.6	52.9	29.7	20 2

d. RAINFALL.—The best idea of the rainfall in this region, as well as over the whole country, and of its distribution through the four seasons, can be obtained by consulting the charts originally published in No. 353 of the *Smithsonian Contributions to Knowledge*, where the whole subject is exhaustively discussed. According to the plan there adopted, of dividing the United States into a number of districts characterized by a general uniformity in the distribution of the rainfall, we have to devote our attention here to the district there referred to under type viii. Its characteristics are given as follows: "The principal maximum late in July, or early in August, with two small adjacent minima, about the middle of April and late in October. The subordinate maxima occur in March and December. Range very large." The observations from which this type curve is constructed are from five stations, all on the coast. The curve shows that the monthly rainfall fluctuates between 0.52 of the mean monthly rainfall (in April) and 1.92 of that mean (in August). Hence the average fluctuation is 140 per cent. of the mean monthly rainfall, or, in other words, in the month of maximum rainfall the fall is 3.7 times as much as it is in the month of minimum rainfall. For convenience of reference the ratios of fluctuation in the other characteristic districts are copied here:

	Per cent. of mean monthly rainfall.	Range.
I. Atlantic coast, Portland to Washington	0.84 to 1.22	38
II. Hudson river valley	0.69 to 1.29	60
III. Upper Mississippi river	0.51 to 1.56	105
IV. Ohio river valley	0.74 to 1.40	66
V. Indian territory and western Arkansas	0.61 to 1.51	90
VI. Lower Mississippi and Red rivers	0.75 to 1.19	44
VII. Mississippi delta and Gulf coast	0.68 to 1.37	69
VIII. Atlantic coast, Virginia to Florida	0.52 to 1.92	140
IX. Western coast, San Francisco to Puget sound	0.13 to 2.45	232

As already stated, the ratios for type VIII were deduced from five stations, all on the immediate seaboard. The points regarding which the distribution of the rainfall farther inland differs from that on the coast will be noticed shortly. This ratio varies, however, within the district considered, and to a considerable degree in different latitudes. The following table, from which the ratio for this region was derived, will prove of interest:

Month.	Fort Monroe, Va., 19 years.	Charleston, S. C., 42 years.	Fort Moultrie, S. C., 17 years.	Savannah, Ga., 23 years.	Fort Brooke, Fla., 17 years.	Mean.
January	0.86	0.65	0.68	0.72	0.51	0.68
February	0.70	0.73	0.66	0.63	0.66	0.68
March	0.85	0.90	1.10	0.92	0.72	0.90
April	0.76	0.48	0.46	0.50	0.38	0.52
May	0.99	0.95	1.01	1.22	0.68	0.97
June	1.10	1.16	1.14	1.13	1.53	1.21
July	1.36	1.63	1.69	1.91	2.60	1.84
August	1.44	1.93	2.02	2.07	2.14	1.92
September	1.19	1.42	1.29	1.15	1.24	1.26
October	0.74	0.79	0.56	0.56	0.49	0.63
November	0.84	0.55	0.56	0.44	0.43	0.56
December	1.17	0.81	0.83	0.74	0.61	0.83

For more complete tables the original article may be referred to. The fluctuation evidently increases as we go south, and it may be assumed with sufficient accuracy, as follows:

	Per cent.
Latitude, 34°–37°; fluctuation	75
Latitude, 32°–34°; fluctuation	145
Latitude, 30°–32°; fluctuation	200

As regards the fluctuation of the *annual* rainfall the region considered does not differ much from New England and the middle states, as the following table will show:

Table of fluctuation of annual rainfall (fluctuation in per cent. of mean annual fall).

Place.	Limits of fluctuation.	Per cent.	Number of years observed.
Brunswick, Me	150–59	91	32
Hanover, N. H	139–79	60	19
Burlington, Vt	145–74	71	27
Boston, Mass	150–67	83	41
New Bedford, Mass	140–74	66	54
Providence, R. I	130–74	56	36
New Haven, Conn	126–76	50	23
Flatbush, N. Y	135–74	61	32
Philadelphia, Pa	143–67	76	43
Washington, D. C	143–62	81	30
Fort Monroe, Va	158–57	101	19
Charleston, S. C	151–54	97	42
Fort Moultrie, S. C	144–79	65	17
Saint John's, S. C	133–58	75	14
Savannah, Ga	145–54	91	23
Fort Brooke, Fla	168–67	101	15
Marietta, Ohio	145–76	69	48
Saint Louis, Mo	163–64	99	31
I. Atlantic coast, Maine to Virginia	123–73	50	63
II. New York and adjacent parts of Canada, New Hampshire, Massachusetts, and Vermont	122–76	46	41
III. Parts of Iowa, Minnesota, Illinois, and Wisconsin*	125–75	50	40
IV. Ohio valley, Ohio, Indiana, Illinois, Kentucky, and part of Missouri	126–71	55	49
V. Indian Territory and Arkansas*	146–62	84	53
VI. Louisiana, Alabama, and West Florida*	140–72	68	36
VII. Atlantic coast, Virginia to Florida*	136–78	58	24

*Only to be considered rough approximations, on account of small number of stations.

The most important fact connected with the rainfall is, however, that its distribution in the mountains and in the water-power district is by far not so variable as on the coast, a fact of the greatest significance as regards the flow of the streams and the amount of power available. I shall, further on, discuss the influence on the flow of the streams which is exerted by the various facts relating to this region, so that at present it is only necessary to mention the fact that, in the case of many of the streams in this part of the country, the rainfall on their water-shed above the fall-line is almost the same in winter as in summer, and even in some cases larger in winter. A glance at the Smithsonian maps will convince one of this fact, and also of the fact that the distribution is irregular, so that there is no gradual change in the law governing it, as we proceed from south to north.

As regards the absolute amount of rain the charts give the best idea, and to them I would refer. The average amount varies according to the latitude and the distance from the coast. The following brief tables will show to what extent:

Table of average rainfall (inches).

	North Carolina and Virginia.			South Carolina.			Georgia.		
	East.	Middle.	West.	East.	Middle.	West.	East.	Middle.	West.
Year	50	40–44	44–50	44	44–50	56	44	44	46
Summer	14	10–14	14–16	14	10–14	14–16	14	10–14	14–16
Winter	10–12	10–16	14	10–12	14–16	16	10	12–16	16

Rainfall table.

Place.	Latitude.	Longitude.	Elevation.	Spring.	Summer.	Autumn.	Winter.	Year.	Number of years observed.
	° ′	° ′	*Feet.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Yrs. mo.*
Gaston, N. C.	36 28	77 38	152	12.12	11.88	9.06	10.34	43.40	4 8
Chapel Hill, N. C	35 58	78 54	570	10.50	10.29	10.68	11.24	42.71	3 11
Fort Moultrie, S. C	32 45	79 51	25	9.75	18.37	9.15	8.24	45.51	17 1
Charleston, S. C	32 47	79 56	20	8.85	17.49	10.20	8.28	44.82	45 5
Camden, S. C	34 15	80 31	240	12.10	18.17	9.10	11.12	50.49	8 6
Saint John's, S. C	33 18	79 56	50	8.84	17.38	8.92	8.33	43.47	13 2
Waccamaw, S. C	33 29	79 17	20	8.28	14.88	10.08	9.96	43.20	9 4
Abbeville, S. C	34 13	82 28	500	13.53	12.11	6.65	17.06	49.35	2 10
Aiken, S. C	33 32	81 34	563	10.78	16.51	8.08	11.88	47.25	12 11
Sparta, Ga	33 17	83 09	550	11.42	14.61	10.22	17.63	53.88	9 0
Savannah, Ga	32 05	81 05	42	10.39	20.81	8.61	8.86	48.67	30 10
Athens, Ga	33 57	83 30	860	10.82	13.17	7.11	12.09	43.19	7 5
Augusta, Ga	33 28	81 53	350	13.19	11.92	8.78	12.89	46.78	11 0
Brunswick, Me	43 54	69 57	74	11.70	11.71	11.42	9.84	44.67	32 1
Southern Maine	....	....	....	9 to 12	10	10 to 14	10 to 12	44 to 50	....
Northern Maine	....	....	....	6 to 9	10 to 12	10 to 12	8 to 10	38 to 40	....
New Hampshire	....	....	....	9 to 12	10 to 14	10 to 14	8 to 10	38 to 44	....
Hanover, N. H	43 42	72 17	530	9.91	11.9	10.58	9.08	40.66	19 0
Massachusetts to New Jersey	....	....	....	12	10 to 14	10 to 14	10 to 12	44 to 50	....
Western New York	....	....	....	6 to 9	6 to 10	8 to 10	6 to 8	28 to 32	....
Cincinnati, Ohio	39 06	84 28	480	11.17	12.67	9.29	9.83	42.96	41 11
Detroit, Mich	42 20	83 00	580	8.51	10.10	8.44	5.79	32.84	39 5
Saint Louis, Mo	38 37	90 16	481	11.71	13.01	8.58	7.39	40.69	40 0

The records are quite incomplete regarding this part of the country, most of the stations at which long records have been kept being on the immediate seaboard. On account of the lowness of the land near the coast and its swampy character the rainfall will increase for a certain distance inland, and will probably reach its maximum between the coast and the fall-line, diminishing from that line inland, but reaching a second maximum in the mountains. Professor Kerr, in his report of the Geological Survey, gives the rainfall in the different sections of North Carolina as follows:

	Inches.
Eastern division	58.1
Middle division	45.6
Western division	58.2
State	53.1

The observations from which these figures were deduced were made principally between the years 1871 and 1875, and from records furnished by Professor Baird it is evident that those years were years of large rainfall all along the southern Atlantic coast, the rainfall being, on the whole, considerably greater than the average at stations where long records exist. Professor Kerr thinks 45 inches too low a figure for North Carolina, and considers 53 inches more nearly correct. It seems to me, however, that the average rainfall for North Carolina should not be so much greater than for Charleston, South Carolina, or Savannah, Georgia. The preceding table, taken from the *Smithsonian Contributions*, shows the results of observation at these places, as well as at others. It will be seen that there are very few places where the annual rainfall amounts to 53 inches, and it seems to me that 45 to 50 inches is not too low a figure for North Carolina, according to all the information that I can at present gather. I have estimated from the Smithsonian charts the amount of rainfall for each river-basin, and the results are given in considering the rivers separately. I have endeavored to make the estimate too low rather than too high, so as not to overestimate the powers.

Snow.—Snow falls in all parts of the region under consideration. The average for three years at five stations in North Carolina gave a mean depth of 6 inches for the state.* In Georgia snow is rare, and seldom impedes communication, although it has been known to fall at several places to a depth of 3 feet.†

Fogs are very rare in all the district considered.

As regards *cloudiness*, Loomis gives the average cloudiness for the New England states as 0.53, and for the southern states as 0.47.‡

Freshets.—All the rivers in this region are subject to quite heavy freshets, not differing much, however, so far as I can learn, from those in the northern states, except as regards cause and times of occurrence. As there is little snow, there are no freshets to correspond with the ice-freshets at the north on the breaking up of the rivers, and

* Professor Kerr's report. † Blodgett's *Climatology*, p. 147. ‡ *Meteorology*, p. 103.

thus one of the destructive elements of the freshets is removed. The freshets are irregular in the times of their occurrence, their duration, and the heights to which the water rises, so that any further remarks concerning them will be postponed until each river is considered by itself.

e. EVAPORATION AND MOISTURE.—The evaporative power of the atmosphere being determined by its temperature and its hygrometric state, a few remarks regarding the latter seem to be called for, the temperature having already been considered. I have, however, been unable to find much information regarding the moisture in the air at different places, but have noticed the fact that the relative humidity of the air seems to diminish as we proceed from south to north in the district under consideration. Professor Kerr, in his report on the geology of North Carolina, gives the results of hygrometric observations at Wilmington and Charlotte, and Blodgett, in his *Climatology*, has given some figures for New Orleans and Saint Louis. It appears from them that the average relative humidity for the year is as follows at these places: Wilmington, 57 per cent.; Charlotte, 65 per cent.; New Orleans, 86 per cent.; Saint Louis, 67 per cent.; London, 80 per cent.

The daily records of the observations in North Carolina show that at no time in the months of June, August, and October (the only ones for which the results are given) does the relative humidity exceed 97 per cent. Only once did it reach 97 per cent., once 95 per cent., and twice 90 per cent. Observations in Atlanta, for eleven months in 1876, give the average relative humidity at about 60 per cent., and show that in nine months of the year the maximum was 100 per cent., and in no month less than 93 per cent. The observations are not extended enough to serve as a basis for any general conclusions, but it seems evident that the moist winds from the Gulf deposit a large proportion of their moisture in the first few miles of their course, and after that deposit less and less, and become drier and drier, thereby increasing the evaporation as we proceed north. Other things being equal, and especially the distribution of the rainfall throughout the year, the southern streams would discharge a smaller proportion of the rainfall in their drainage-basins than the northern ones in the district considered. But the distribution of the rainfall is not the same, so that this conclusion cannot be drawn at once.

Before proceeding to discuss the effects exerted by the facts which have been stated on the water-power of the district under discussion it is desirable to show what the essential elements of a water-power are, and how they may be varied by the various climatic and other influences.

FLOW OF STREAMS.

The essential elements of a water-power are the fall and the quantity of water; and the amount of fall being a fixed quantity, capable of being measured once for all, and therefore not needing discussion, it is necessary to determine the amount of water that a given stream will afford at a certain point and the variation in the flow from month to month.

The average amount of water carried past a certain point in a year depends upon the amount and distribution of rainfall, the area of the drainage-basin, and the character of that basin. All the water carried by is derived from the rainfall, but of the total rainfall a certain amount is lost in the following ways: by percolation and discharge through subterranean channels; by evaporation from the soil and the surfaces of streams; by absorption through the roots of trees, shrubs, and grasses, and subsequent evaporation. The amount discharged by the streams will be greater as these sources of loss are diminished, and the problem before us is to determine for each particular case what proportion of the rainfall is so discharged; and we must, moreover, endeavor to find out the laws regulating the distribution of the flow through the year, and from year to year. In the case of most streams the flow varies greatly from day to day, and from month to month, being occasionally in times of freshet 50, 100, and even several hundred times its minimum volume. Thus the table given further on shows that the Potomac river at Cumberland has been known to discharge a quantity 716 times as great as its minimum discharge, while the maximum discharge of the Merrimac is only 44 times its minimum discharge. A great fluctuation in flow is evidently an obstacle to the extensive use of water-power, making it necessary to depend only on the flow at times when the stream is low, or to use auxiliary steam-power, or to store the freshet water in reservoirs, and so increase the flow in dry seasons. It is necessary, therefore, to discuss, to some extent, the total amount discharged by streams (or the proportion of the rainfall flowing off), and the manner in which that total amount is distributed through the year. As regards the first of these questions, it has generally been customary to assume a certain fixed proportion of the annual rainfall as flowing from the surface and discharged by the streams; but it has always been recognized that the proportion to be thus assumed varies greatly according to numerous circumstances, such as the area and form of the drainage-basin; the distribution of the rainfall through the year, as well as its amount; the extent of the forests; the number and extent of lakes; the character of the soil and rocks, and the state of cultivation; and all of these factors affect not only the total discharge of a stream, but also its distribution. With a given water-shed, in any particular year, a certain proportion of the rainfall will be discharged and distributed in a certain way, but both that proportion and that distribution are liable to change if any one of the above conditions are altered. Thus the greater the area of the water-shed the more uniform the flow, other things equal, because streams draining small areas are more subject to the effects of sudden rains than those draining large ones; and while in the former case there may be weeks at a time when no rain falls on the basin, and the stream draining

it almost dries up, in the latter case there will probably be frequent rains on some part or other of the basin. The table given further on illustrates this point by showing that, as a rule, the ratio of maximum to minimum discharge is greater in the case of small streams than in that of large ones. And, in like manner, the form of the drainage-basin exerts a certain influence. The distribution of the rainfall is a very important point, and as an example of the great variability of the proportion of the rainfall discharged from the same water-shed in different years the case of the drainage area of the Albany water-works may be cited, where from an area of 2,600 acres in 1850, between May and October, inclusive, 41½ per cent. of the rainfall was carried off by the streams, while in 1851, within the same period (from May to October), 82.6 per cent. was discharged.* Hence it is that the year of minimum rainfall may not be the year in which the streams get lowest, or the one in which the season of absolute minimum flow occurs. An eminent authority has remarked: "This (the year with the season of least flow) is not necessarily the year of least rainfall, nor even the year of greatest apparent drought, but is the result of such a distribution of the rainfall that the excess of water over the amount needed for sustaining vegetation and supplying losses by evaporation is very small for several successive months." † The proportion of the rainfall discharged by streams is therefore a very uncertain and variable quantity, varying not only for different streams, but for the same stream in different years; and it is evident that the attempt to deduce the distribution of the flow of streams by taking certain proportions based on the rainfall is still more uncertain. Hence it is that some eminent engineers have given up the use of any proportion at all in calculations regarding the capacity of streams to furnish water-supply, and have adopted for this climate a certain fixed number of inches of rainfall as available. Mr. Croes has remarked in another place ‡ that "the few records that exist of the flow from known drainage areas establish the fact that not over 15 inches per annum can be depended upon on the Atlantic slope, and many engineers who have devoted a good deal of attention to the subject are very decided in their opinion that not more than 11 inches should in any case be calculated on". The following table is copied from the same source:

Small annual yield of streams.

Stream.	Drainage area.	Year.	Rain.	Discharge.
	Sq. miles.		*Inches.*	*Inches.*
Eaton brook, N. Y.	9.4	1835–'36	35.68	16.67
Patroon's creek, N. Y.	12.5	1851	36.75	17.53
Cochituate, Mass	19.0	1870–'71	42.96	12.62
West branch of Croton, N. Y.	20.0	1870–'71	39.36	18.88
Croton, N. Y	339.0	1864	40.80	14.89
Croton, N. Y	339.0	1872	40.74	19.00
Connecticut, Conn	10234.0	1877	....	21.71

In order to utilize all the discharge given in the last column a certain amount of storage-room will be required, owing to the variation of the flow in different months.

It may not be out of place to devote a few lines here to a closer consideration of the causes affecting the fluctuations in the flow of streams. Evaporation, the principal source of loss, acts in different months with very different degrees of intensity, being generally greatest in the summer months and least in the winter. It is sometimes the custom, in calculating the amount of water-supply available for the use of a town, to assume a certain proportion of the rainfall of each month as collectible or as discharged through the streams, that proportion varying from 20 or 30 per cent. in summer months to 70 or 80 per cent., or even over 100 per cent., in others. Now, if we assume that the rainfall at any particular time reaches the streams within a short time after it has fallen, say within a month or so, then, if the rainfall is uniformly distributed throughout the year, the flow of the streams will decrease as the evaporation increases, and will be several times greater in some month (the month of maximum flow) than in some other month (the month of minimum flow). If, now, the rainfall be so distributed that in the months when the evaporation is *least* the greatest rainfall occurs, it is evident that the proportion of the rainfall discharged will be greater than in the first case, while the variability of the flow will also be greater. In this case, then, a larger amount of water will be available, but the storage necessary will also be larger, while the minimum and low-season flow of the stream, without storage, will be less than before.

Again, if the rainfall be so distributed that the greatest rainfall occurs in those months in which the evaporation is greatest, the proportion of the rainfall discharged by the streams will be less than in the first case, but the flow will be more uniform. In this case, then, a smaller amount of water will be available, but the necessary storage will be less, while the minimum flow of the stream, without storage, will be greater than in either of the previous cases. Hence we see how the distribution of the rainfall and the amount of the evaporation affect the flow of the streams,

*HUGHES, *Waterworks*, p. 332.
† Newark Aqueduct Board, Report on Additional Water Supply, by J. J. R. Croes and G. W. Howell, 1879.
‡ *Engineering News*, March 20, 1880, p. 104.

and by considering these, as well as the other elements affecting water-power, we may be able to judge of the relative value of two streams, and to form some estimate of their flow, even if no gaugings are at hand, although such estimates are very rough and liable to be greatly in error.

Two elements of a good water-power are, large flow, or large proportion of rainfall available, and uniform flow. The flow may be large, but if it is very variable the storage-room necessary to utilize it all may be too large, while a small flow, if uniform, could be utilized without any storage at all (except where it is desired to concentrate the power into less than twenty-four hours). But the remaining factors above named affect very materially the flow of streams, both in amount and in constancy, viz, soil, forests, lakes. The effect of these is felt in so many ways that it would not be the place here to discuss them extensively. But, as showing what principles have guided me in making my estimates of the flow of the various streams, I may be permitted to sum up here briefly these effects. A deep and porous soil, if underlaid by an impervious stratum, down to which the streams have cut their beds, has the effect of diminishing the evaporation and rendering the flow of the streams more constant. In some cases, however, and especially when the streams have not cut down to an impervious bed (that sheds the water that percolates to it), a deep and pervious soil is accompanied by considerable loss by flowage in subterranean courses, so that the flow of the streams may be diminished. It does not seem as though this were the case in the southern states. The action of lakes in regulating flow is evident, but it is next to impossible to estimate it numerically. They exert a more important influence in this respect than any other factor entering into the question. As regards forests, I am constrained to speak of their action somewhat at length because of the fact that, on account of the climatic conditions in some parts of the district under consideration, their influence may be overestimated. Although authorities are not agreed as to whether forests increase the actual amount of rainfall, the weight of evidence seems to be tending to prove that they do not. All are agreed, however, that they act as great regulators of the flow of streams. According to the results of the experiments at the Bavarian experiment stations the action of forests is as follows:*

1. They decrease the temperature of the ground, but in winter the effect is inappreciable.
2. They decrease the temperature of the air during the daytime, but in winter to an inappreciable extent, and increase it during the night in winter much more than in summer.
3. They have no influence on the absolute humidity of the air, but they increase greatly its *relative* humidity, and to a large extent at all seasons, but greater in summer than in winter.
4. They decrease evaporation from a free water-surface, and to an almost equal extent at all seasons, and also the evaporation from moist earth.
5. Trees themselves evaporate so much that the total evaporation from woods is greater than from open ground.
6. They decrease the amount of rainfall which reaches the ground by intercepting part of it by their leaves and branches.
7. They exert no influence on the distribution of rainfall throughout the year.
8. They have but a small effect, if any, in increasing the rainfall, but that effect is much greater in summer than in winter, and increases with the elevation above the sea.
9. They have no appreciable effect in increasing the total quantity of water penetrating the ground, but in winter they *decrease* that quantity, while in summer they increase it very considerably. The forests, therefore, diminish the quantity of water flowing directly from the surface in summer, and by storing it up, to be given out gradually, contribute to the constancy of the streams. (See page 20 for further remarks.)

I will now proceed to explain the general method I have followed in estimating the flow of the streams in this district. In calculating the amount of water-power available I have considered the flow of streams chiefly with reference to four quantities, viz:

1. The absolute minimum flow.
2. The minimum low-season flow.
3. The maximum flow available with storage.
4. The low-season flow in ordinarily dry years, but not the driest.

a. The absolute minimum flow determines the maximum power which the stream will afford, at a given point, *at all times;* but as this minimum-flow generally occurs during a period of not over a few days at intervals of several years, it is not of so much importance as the other quantities, and if only this flow is utilized there will be a large amount of water wasting, even in the low season, for years in succession. The amount of this flow is best approximated to, probably, by assuming a certain discharge per square mile of water-shed, varying with the area of the water-shed and the local and climatic conditions. In estimating this flow I have made use of the results given in the table on page 20.

b. The minimum low-season flow is the smallest average amount flowing during a period of from six to three weeks, *generally* in summer, when the stream is at its lowest. In most years, the average flow during the season of least flow exceeds this amount. It may therefore be depended upon at all times, except for intervals of a day

* EBERMAYER: *Die physikalischen Einwirkungen des Waldes auf Luft und Boden, und seine klimatologische und hygienische Bedeutung.* Berlin, 1873.

or two, perhaps several days at a time, during which the flow approaches its absolute minimum, and may be rendered available at all times by a small amount of storage. In ordinary years there will be an excess almost all the time.

This minimum summer flow can probably be best estimated by comparison with experimental results, some of which are given in the table on page 21. But in most cases I have estimated it as follows:

1. Seven-tenths of the mean annual rainfall may, in general, be considered the minimum rainfall.

2. Forty per cent. of this may, on the average, for tolerably large drainage basins, be considered to be discharged by the streams, subject to variation, however, according to local and climatic conditions; but in no case should the amount determined in this way as the total amount discharged in a year exceed say 10 to 13 inches. If it does, not over 10 to 13 inches should be assumed. The storage necessary to render this flow available at all times I am unable to calculate with the data at hand.

3. The distribution of this flow through the year may be estimated from the results of the table on page 21, bearing in mind, however, in estimating the coefficient which expresses the proportion of the mean monthly rainfall which is discharged in the driest month, the various remarks concerning the district considered, on pages 22 to 24.

c. By increasing the storage-room a larger flow may be rendered available. In regard to the amount of increase possible, I have assumed that 10 to 13 inches is all that can be depended on permanently. Perhaps 11 to 13 inches may be assumed for New England and the middle states. In the region we are considering, according to the remarks on pages 16 to 18, I have modified these figures by taking them somewhat smaller, on the supposition that the percentage of rainfall discharged is smaller. This will agree pretty closely with the available annual flow in very dry years; for if we take 40 per cent. of the rainfall as available, and 0.7 of the mean annual rainfall for the rainfall during a dry year,* we shall have for a rainfall of 40 and 50 inches, respectively, 11.2 and 14 inches available.

Any calculations respecting the amount of storage necessary can only be rough approximations, and may, perhaps, prove entirely fallacious, on account of the total absence of data regarding the flow of the streams in different months. A comparison and a study of all the data that I can find regarding other streams has led me to the opinion that the storage necessary to render the above quantity available will be between 2 and 4 inches on the water-shed, varying according to the various local and climatic conditions (see pages 8 to 16) and according to the area of the water-shed, being greater for small water-sheds than for large ones. But this is a very rough approximation.

d. The mean low-season flow in dry years (but not the driest) I have approximated by taking 11 to 16 inches of rainfall available, and taking a certain proportion of this as the amount flowing in the one or two months of the season of low flow, according to the table on page 21, modified somewhat according to circumstances; or, in many cases, by simply increasing by one-seventh the estimate of the minimum low-season flow. Without storage, this flow may generally be depended upon, except in low seasons of very dry years, when the supply may be deficient for several weeks at a time. *In ordinary years one-quarter more may be calculated upon.*

In all cases referring to low-season flow the flow will generally be at least twice as great for nine months in the year.

Any attempt to utilize the mean annual flow would result in failure of supply in very dry years.

It is a question to be determined in each case separately, from financial and other considerations, how much power it will be desirable to utilize, with due consideration of such points as the length of time during which the supply will fail and cost of supplementary steam-power.

In view of the uncertainty of this subject, the estimates which I have made must all be considered only rough approximations, but on account of lack of data I am unable to make them more reliable.

* FANNING: *Treatise on American Water-Supply Engineering.*

The following tables have already been referred to, and are compiled from various sources:

Table showing extremes of flow for some American streams.

River.	Place.	Drainage area, square miles.	Mean rainfall, inches. Spring.	Summer.	Autumn.	Winter.	Year.	Length flowed, miles.	Remarks on character of drainage basin.	Extremes of flow. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.	Minimum, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	Authority and remarks.
Merrimack		3,598.00	10	11	13	9	43		Lakes and artificial reservoirs. Wooded.		1,638.00		0.414		J. B. Francis, quoted by J. P. Kirkwood.
Merrimack	Lawrence	4,136.00	10	11	13	9	43		Lakes and artificial reservoirs. Wooded.	96,782	2,192.00	44	0.530		C. Herschel.
Concord	Lowell	352.00	11	11	12	10	44			4,449	59.84	74	0.170		C. Herschel.
Sudbury	Framingham	78.00	11	11	12	10	44		Hilly and swampy. One-sixth to one-eighth wooded.	3,228	2.80	1,153	0.036		A. Fteley.
Charles		236.00	11	11	12	10	44		Hilly and rolling		44.00		0.188		J. P. Kirkwood.
Hale's Brook, Mass.		24.00	11	11	12	10	44				3.24		0.135		J. P. Frizell.
Connecticut	Hartford	10,234.00	10	12	12	10	44		Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.	207,443	5,219.00	40	0.510		T. G. Ellis.
Connecticut	Dartmouth	3,287.00	10	12	12	10	44		Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.		1,006.00		0.306		C. Herschel.
Housatonic		790.00	12	12	12	10	46				130.00		0.165		H. Loomis, Rept. N. Y. Com. Pub. Wks., 1879.
Croton		338.82	12	13	13	10	48			25,367	50.80	500	0.150		J. J. R. Croes and G. W. Howell.
W. Br. Croton		20.37	12	13	13	10	48			1,109	0.407	2,722	0.020		J. J. R. Croes.
Passaic		855.00	12	14	12	10	48		Some lakes and swamps. Hilly.		178.00		0.208		J. J. R. Croes and G. W. Howell.
Passaic		981.00	12	14	12	10	48		Some lakes and swamps. Hilly.	19,944	225.60	88	0.230		J. J. R. Croes and G. W. Howell.
Delaware	Lambertville	6,500.0±	11	11	11	9	44		Hilly and rolling. Many lakes. Well wooded.	350,000	2,000.00	175	0.300		Ashbel Welch.
Schuylkill	Philadelphia	1,800.00	12	14	10	9	45		Hilly and rolling. No lakes. Some reservoirs.		307.0 to 378.0		0.17 to 0.21		E. F. Smith and H. P. M. Birkinbine.
Hackensack		84.00	12	14	12	10	48		Flat. No lakes or reservoirs, except mill-ponds.		27.00		0.33(?)		C. D. Ward.
Ohio	Pittsburg	19,900.00	10	12	9	10	41		Hilly and mountainous. No lakes. Wooded.		2,271.00		0.114		J. H. Harlow.
Potomac	Cumberland	920.00	10	12	9	8	39	65	Narrow valleys. Steep slopes. Wooded. No lakes.	17,900	25.00	716	0.022		W. R. Hutton and Patterson.
Potomac	Dam No. 5	4,640.0±	11	12	9	8	40	153	Narrow valleys. Steep slopes. Wooded. No lakes.	92,772	363.00	255	0.0783		Quoted by W. R. Hutton.
Potomac	Great Falls	11,476.00	12	13	9	8	42	244	Country more open. No lakes.		1,063.00		0.093		W. R. Hutton.
Rock Creek	Hoyle's Mill	64.40	11	12	11	8	42	18			7.50		0.114	0.458	Quoted by W. R. Hutton.
Kanawha	Charleston pool	8,900.00	12	13	9	10	44	270	Mountainous. Steep. No lakes. Wooded.	120,000±	1,100.00	110	0.123		Gill, Scott, and Hutton.
Greenbriar	Mouth of Howard's Creek.	870.00	11	12	8	9	40	60	Mountainous. Steep. No lakes. Wooded.		97.00		0.120		McNeill.
Shenandoah	Near Port Republic.	770.00	12	13	8	8	41		Hilly. Limestone. No lakes. Many springs.		128.00		0.167		James Herron.
James	Richmond	6,800.00	12	12	9	10	43		Mountainous in upper part. No lakes. Wooded.		1,300.0+		0.191		H. D. Whitcomb and W. E. Cutshaw.
Neuse	Near Raleigh	1,000.00	12	13	10	10	45		Open. Clay and loam. No lakes. Few extensive woods.					0.193	W. C. Kerr, low water.

Table of monthly flow in dry years.

Rivers.	Drainage area, square miles.	Flow in inches on water-shed.													Ratio of monthly to mean flow.											
		Dryest month.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.	Total for the year.	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.
Croton	339	0.20	0.35	0.53	0.63	0.87	0.94	1.52	1.63	1.80	1.90	2.08	2.27	14.72	0.16	0.29	0.43	0.51	0.71	0.77	1.24	1.33	1.47	1.55	1.70	1.85
Concord	352	0.25	0.32	0.36	0.43	0.54	0.68	0.85	1.07	1.36	1.70	2.15	3.62	13.33	0.22	0.29	0.32	0.39	0.49	0.61	0.76	0.96	1.28	1.53	1.94	3.26
Merrimack	4,136	0.68	0.70	0.77	0.85	1.00	1.13	1.30	1.53	1.98	2.55	3.22	5.42	21.13	0.38	0.40	0.44	0.48	0.57	0.64	0.74	0.87	1.12	1.45	1.83	3.08
Connecticut	10,234	0.65	0.68	0.71	0.74	0.88	0.90	1.28	1.51	1.80	2.02	3.28	4.71	19.16	0.41	0.43	0.45	0.46	0.55	0.56	0.80	0.95	1.13	1.26	2.05	2.95
Schuylkill*	1,800	0.27	0.30	0.38	0.40	0.53	0.62	0.68	0.79	0.88	0.98	1.08	1.59	8.50	0.38	0.42	0.54	0.57	0.75	0.88	0.96	1.12	1.24	1.38	1.52	2.24

Table of monthly average flow for a series of years.

Croton	339	0.56	0.95	1.12	1.21	1.43	1.82	2.30	2.57	2.77	3.02	3.60	4.00	25.35	0.26	0.45	0.53	0.57	0.68	0.86	1.09	1.21	1.31	1.43	1.70	1.90
Concord	352	0.39	0.46	0.51	0.61	0.76	0.96	1.25	1.52	1.92	2.38	3.00	4.86	18.62	0.25	0.30	0.33	0.39	0.49	0.62	0.81	0.98	1.24	1.53	1.93	3.13
Merrimack	4,136	0.77	0.88	1.06	1.26	1.52	1.80	2.12	2.49	3.03	3.73	4.63	6.56	20.85	0.31	0.36	0.43	0.51	0.61	0.72	0.85	1.00	1.22	1.50	1.86	2.63
Connecticut	10,234	0.75	0.85	0.91	1.10	1.34	1.58	2.00	2.36	2.81	3.27	4.52	6.26	27.75	0.33	0.37	0.39	0.47	0.58	0.68	0.87	1.02	1.21	1.41	1.96	2.71

Table of monthly flow in dry years of streams of small drainage area.

Cochituate	19.00	0.08	0.41	0.46	0.47	0.70	0.88	0.97	1.03	1.11	1.31	1.47	2.26	11.15	0.09	0.14	0.50	0.51	0.75	0.95	1.03	1.11	1.20	1.41	1.58	2.43
Croton, Western Branch	20.37	0.10	0.17	0.46	0.53	0.67	0.84	0.98	1.02	2.31	3.37	3.41	5.40	19.26	0.06	0.10	0.28	0.33	0.42	0.52	0.61	0.64	1.44	2.10	2.13	3.37
Sudbury	76.30	0.11	0.16	0.25	0.39	0.57	0.79	1.06	1.40	1.79	2.21	2.77	5.09	16.50	0.08	0.11	0.18	0.28	0.41	0.57	0.77	1.01	1.29	1.60	2.01	3.69
Passaic headwaters	50–100	0.11	0.15	0.21	0.27	0.49	0.67	0.90	1.22	1.77	1.87	2.13	3.65	13.44	0.10	0.13	0.19	0.24	0.44	0.60	0.80	1.09	1.58	1.67	1.90	3.26

* Charles G. Darrach, in *Engineering News*, April 3, 1880, p. 122.

The month of least flow (the driest month) varies considerably from year to year, falling sometimes in the summer and sometimes in the winter, and the months do not succeed each other in the order of dryness. As a rule, however, the driest months fall in summer, although sometimes the difference is not very pronounced. (See a paper by Mr. Clemens Herschel, "The Gauging of Streams." *Transac. Am. Soc. Civ. Engrs.*, vol. vii, 1878, p. 236.) The last three tables are principally from Mr. Croes' report to the Newark Aqueduct Board.

In describing the separate water-powers I have therefore given four estimates. For convenience of reference I will recapitulate them here, noting briefly their exact meaning:

1. Absolute minimum can be depended upon *always*, and with no storage at all. Large waste all the time, except for a few days at a time in intervals of several years.

2. Minimum low-season flow, with no storage, can be depended upon at all times, except for a short time in some dry seasons—perhaps for a few days in the dry season of each year. With small storage can be depended upon all the time.

3. Mean flow in very dry years.—*Maximum amount permanently available with storage.* Storage capacity as already discussed. With larger storage a greater amount could perhaps be utilized for several years in succession, but not permanently.

4. Low-season flow in ordinary dry years, without storage, can be depended upon generally, except in the low season of dry years, when the supply will be deficient for, perhaps, several weeks; in very dry years, when the supply will be deficient for a longer time, and in ordinary years, when the supply may be deficient for a few days at a time; can be rendered permanently available by storage. *The low-season flow of ordinary years* can be depended upon less than the above, but generally for nine months of every year.

TIDAL WATER-POWER.

There is no tidal power either used or available in the district considered, partly because there are no facilities for storing water, and partly because, as is evident from the topography of the country, there are no facilities for location of buildings on a low and swampy coast.

TOTAL AVAILABLE POWER.

It is customary to attempt to estimate the total available power of a district by assuming the average elevation and the quantity of water discharged. Such estimates have little value, because a large proportion of the power so estimated is, in fact, unavailable, on account of topographical features. In regard to the region under consideration, however, it is to be noticed that as the elevation of the Atlantic plane, at the foot of the mountains,

is much greater than in the states farther north, varying from 1,200 feet in North Carolina, at the sources of the Catawba, to 500* feet in Virginia and 100 to 300 feet in Pennsylvania,* the total theoretical power in the region we are considering will be very large in proportion to its area, especially if we exclude the eastern division from consideration.

After having presented the general features of the district under consideration, briefly pointed out the general principles relating to the amount of power available, and explained the method used in calculating it, it is now only necessary to show how, in the application of those principles, the general characteristics of the region show their effects and are to be taken into account.

6.—General results.

1. It follows from the position of the region that the warm and moist SW. winds from the Gulf of Mexico traverse its whole extent. Hence the rainfall is greatest (62 inches) in Alabama and southern Georgia, while the evaporation is comparatively small, because the air is moist, and the rainfall diminishes to 44 inches and less in North Carolina and Virginia, while the air becomes drier and the evaporation greater. Above North Carolina the greater part of the rain comes from the Atlantic, while south of Virginia most of it comes from the Gulf. This fact—that the evaporation increases toward the north—has an important bearing on the flow of the streams, which will be referred to further on.

2. From the topography it follows that all the water-power of importance is in the middle division. In the eastern division the streams are too sluggish, and in the western they are too small and inconstant. Although the middle division is very favorably disposed for water-power, it is unfortunate that in the eastern division, just where the streams are the largest, the conditions are not favorable. The middle division is, topographically, very favorable for power. The fall of the streams is great, but as a whole tolerably uniform, and their volume moderately large. They cross the ledges of rock at large angles, forming many rapids, rifts, or falls in all parts of this region. These ledges, being composed of hard, durable, and impervious rocks, generally granite or similar rocks, insure the permanence of the powers, and afford everywhere good sites for dams. The shape of the river valleys is such as to render the utilization of the power in most cases easy, there being only a very few instances of anything approaching the cañon structure. The facilities for storing water are, on the whole, good, though the shape of the valleys does not seem to be *particularly* favorable; for in the mountains the fall is too great and the valleys too narrow to afford *large* reservoir room, while lower down the rivers are bordered by fertile bottom-lands, which it might be inadvisable to overflow, and besides, as the streams are tolerably large, it would be difficult to store sufficient water to increase the power much. In the matter of storage this region is notably less favorable than such states as Maine and Pennsylvania. The absence of lakes, also, operates unfavorably on the volume and constancy of the streams, especially in the upper parts, and this is counteracted by the action of the forests perhaps to a less extent than might be supposed. (See below.)

The country in the middle division being moderately hilly, the rainfall is neither precipitated suddenly into the river channels, rendering them subject to sudden freshets, nor is it discharged too gradually, so as to render the evaporation abnormally large. On the contrary, the depth and perviousness of the soil, the fact that it is everywhere underlaid with hard and impervious rock, and that the rivers have cut their channels down to this rock-bed, contribute to the volume and constancy of the streams, and diminish the loss by evaporation and by subterranean flowage. This depth of soil, serving to store the waters, is especially beneficial in view of the variability of the rainfall, in which respect some parts of this region stand at a disadvantage, which is thus, to some extent, compensated for. In Maine, for instance, the soil is very shallow compared with that in North Carolina, but the rainfall is very equally distributed throughout the year. (See page 17 for further remarks on this subject.)

3. The influence of the forests in the western division is favorable, yet not to such an extent as might be supposed, according to what has been said regarding the influence of woods in winter and in summer. In fact, there is reason to believe that at least in the northern parts of the region considered less water percolates into the ground in winter, to be stored and given out by springs, than in open ground. From the experiments which have been referred to, the conclusion has been drawn for Germany that the cutting down of forests has the effect in winter of increasing the discharge of springs and causing a higher average stage of the water in the streams than existed before.† In hot regions, and in summer, the cutting down of woods has the opposite effect, but it does not seem improbable that, for the district considered, the effect would be to a certain extent as stated, especially if (as is the case in the western part of the district in many cases) the rainfall is greater in winter than in summer. For this reason it is easy to overestimate the effect of the forests as regulators of flow. Their effect is certainly very much smaller than in regions where the rainfall is greater in summer than in winter, in which case their effect is very beneficial and only exceeded by that of lakes or artificial reservoirs and surface materials. The fact that the

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* Guyot.

†Ebermayer: *Die physikalischen Einwirkungen des Waldes auf Luft und Boden, und seine klimatologische und hygienische Bedeutung.* Berlin, 1873, p. 223.

mountains in this district are covered with soil is one of great importance, and on this account the flow of the streams will be much more constant than it would otherwise be.

4. I have already alluded to the winds and the position of this region as affecting its water-power. As regards temperature, it is, of course, higher in this region than in New England. In summer the difference is some 12°; in winter, over 20°; and for the year, in the middle division, 12° to 15°. The average temperature in winter is far above the freezing point; hence the streams rarely freeze over. Trouble with ice is almost unknown, and, in this respect, this region has a great advantage over the more northern states, which is, however, partially offset by the fact that the evaporation is greater.

Mr. Wells, in his report on the water-power of Maine, dwells upon the fact, which he says is founded on the testimony of persons who have had the largest and most varied experience in manufacturing in Maine and other states, that operatives can accomplish much more in winter than in summer, or in cold than in warm states. I quote Mr. Wells' remarks on this point:

> It is well known that at the large majority of manufacturing labors the burden of the day's work is felt by the operative to be much heavier in summer than in winter. The cold of the latter season can be so guarded against and mollified that throughout the whole establishment precisely, or very nearly, that temperature can be secured which is most contributive to vigorous exertion. But the heat of summer, pervading and penetrating everything, and brought in at every open window with the necessary supplies of fresh air, cannot be shut out. It cannot be qualified. It oppresses the worker with a languor rarely experienced in out-of-door avocations, and renders it impossible for him to do so much or do so well as he can easily do in cool weather. Accordingly, the evidence is that in Maine, where the summer temperature is low, where it rises above the point of comfort for but a few days for the whole season, operatives, circumstanced equally in every other respect, accomplish more than in the interior and more southern states by the truly remarkable fraction of 10 per cent.

It must, however, be borne in mind that although in warmer climates the operatives are unable to accomplish so much, yet, on the other hand, the expense for heating the factory buildings is greatly reduced, and that, further, as the operatives can live more cheaply on account of not needing so much artificial heating in their houses, their wages may be much less in proportion. In fact, it is stated that the wages paid to operatives in cotton factories in the southern states is 34 per cent. less than in the New England states.* The table of maximum observed temperatures shows that the maximum observed temperature in Maine is about the same as in Georgia. The following table of the mean temperatures of the hottest and coldest months of the year will enable a comparison to be made between the New England states and the southern states, and will show that the difference is not so great as is generally supposed.

Table of mean temperatures of hottest and coldest months in various places.

Place.	Number of years of observation.		Mean temperatures of hottest month.	Mean temperatures of coldest month.
	Yrs.	*Mos.*	*Degrees.*	*Degrees.*
Bath, Me	10	7	68.71	23.23
Castine, Me	40	0	64.82	21.41
Brunswick, Me	51	3	67.44	20.10
Newport, R. I	34	8	70.93	25.84
Providence, R. I	40	0	70.14	29.40
New Haven, Conn	86	0	71.69	26.46
Hartford, Conn	16	7	72.14	29.11
Manchester, N. H	14	1	72.94	23.84
New York, N. Y	24	5	72.93	29.36
Newark, N. J	21	11	75.06	29.78
Philadelphia, Pa	51	0	75.20	29.40
Harrisburg, Pa	29	3	78.63	30.67
Baltimore, Md	36	0	77.35	33.00
Washington, D. C	12	3	78.26	34.09
Fortress Monroe, Va	45	5	78.73	41.10
Fort Johnston, N. C	15	10	81.64	49.10
Chapel Hill, N. C	20	0	78.38	40.40
Asheville, N. C	6	6	74.00	37.00
Aiken, S. C	8	8	78.80	44.15
Camden, S. C	9	9	80.64	42.71
Charleston, S. C	24	8	80.22	49.33
Columbia, S. C	4	11	78.78	43.71
Fort Moultrie, S. C	32	11	81.94	50.28
Athens, Ga	6	6	76.33	44.58
Atlanta, Ga	5	2	77.50	40.90
Augusta, Ga	21	7	82.16	46.68

*Address of Hon. E. Steadman, before the convention of the Georgia State Agricultural Society, August, 1876. According to the census of 1870, the average wages paid to operatives in cotton factories in various states was as follows, in dollars, per annum: Maine, 272; New Hampshire, 311; Vermont, 277; Massachusetts, 311; Rhode Island, 310; Connecticut, 270; Pennsylvania, 276; Maryland, 236; Virginia, 132; North Carolina, 130; South Carolina, 230; Georgia, 222. The wages will depend somewhat on the quality of goods manufactured, but the average is evidently much less in the south.

Most of the stations in the southern states are in the eastern division, where the weather is much warmer than in the middle and western divisions, where the water-power is. The table shows that at Athens and Atlanta, Georgia, which are the best types of the middle section, the mean temperature of the warmest month is not much different from that in the middle states, although Maine, it is true, has a lower temperature by some 10°. It seems to me, however, that this effect of temperature has been overestimated, and that, so far as it alone is concerned, the advantages in the southern Atlantic states more than counterbalance the disadvantages.

5. As regards the rainfall, its distribution throughout the year on the water-shed of each river is to be carefully considered. Variability in this distribution may not be a disadvantage, but on the contrary, if the summer fall is greater than the winter fall, the flow of the streams will be more regular, other things being equal. In determining the ratios to be used in estimating flow I have been influenced by this consideration, and if of two streams, similar in other respects, one has more rain in summer than in winter, and the other more in winter than in summer, I have taken the minimum flow of the former considerably greater than that of the latter. Differences in the evaporation in different parts of the district also come into consideration. If the other climatic conditions remained the same, the effect of variability in the rainfall would be seen in a corresponding variation in the flow of the streams, and in those seasons when most rain fell the flow of the streams would be greater. Yet in the New England states, as well as in the southern states, the streams are lowest in summer, even when more rain falls in that season, showing that the evaporation in that season is more than sufficient to make up for the greater rainfall. It is true that in the North there is a winter drought, caused by the snow lying so long on the ground, so that little of the precipitation reaches the streams; yet, although in some cases the driest month, or the month when the streams are lowest, falls in the winter, in general the summer drought is greater than the winter drought. On account of the increased evaporation, the southern streams will, in all probability, discharge a smaller proportion of the rainfall on their drainage areas than those in New England. Finally, the effect of soil and lakes must not be overlooked in comparing this region with New England, and in estimating the flow of the streams.

The foregoing remarks have been made because it is necessary to present the principles which have guided me in making my estimates. The conditions determining the flow are, however, so various, that they cannot all be given due weight, even if they were all accurately known; so that the only safe guide in practical questions regarding flow is a series of gaugings extending over a number of years. But as I have not a single such series for the district considered I am obliged to resort entirely to estimate. Every engineer can form his own conclusions from the data at hand, and many may not be disposed to approve of the figures given.

I.—THE CHOWAN RIVER AND TRIBUTARIES.

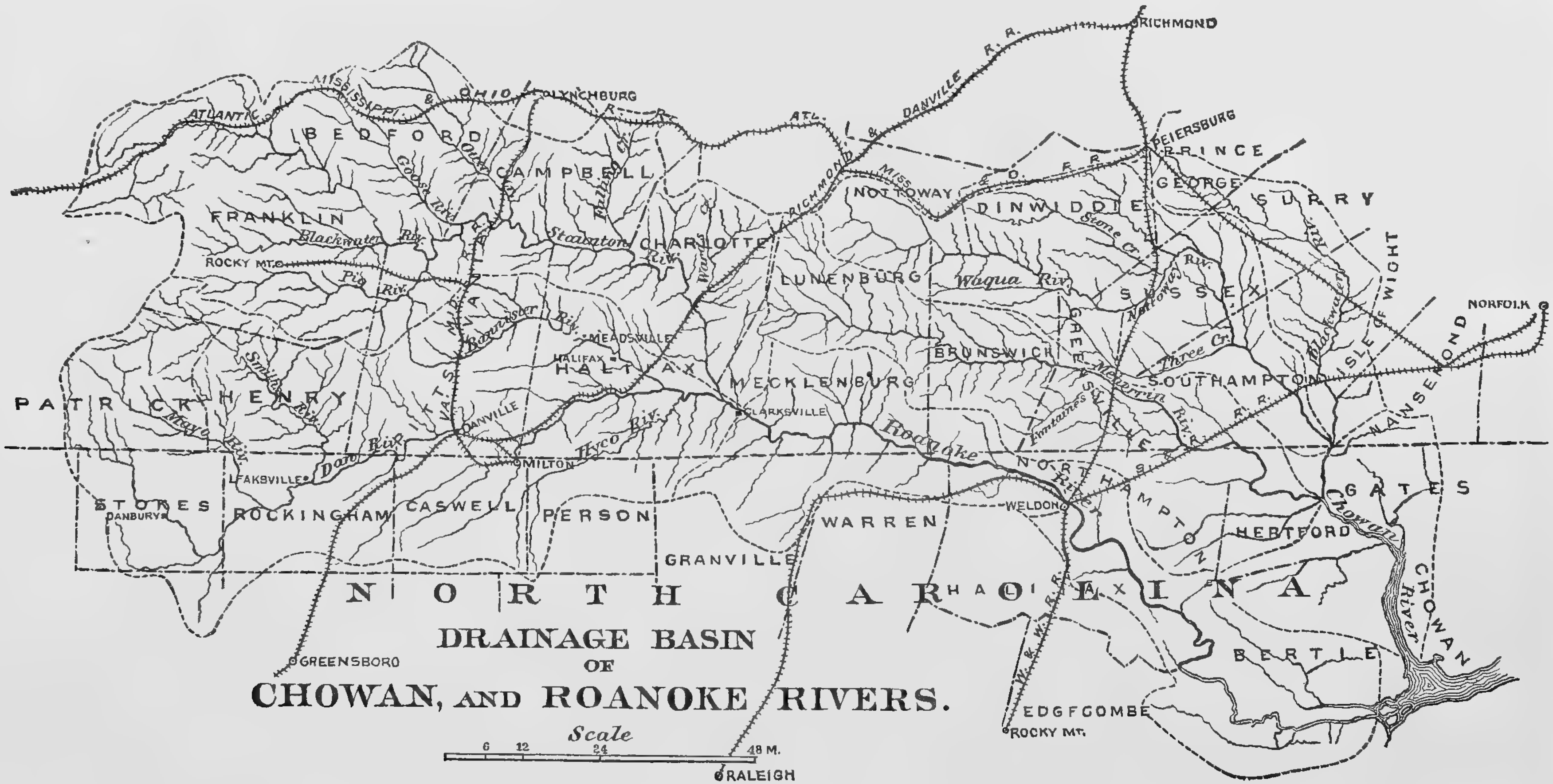
THE CHOWAN RIVER.

The first river south of the James worth considering is the Chowan, for although there is no water-power on the main stream there is some on the tributaries. The Chowan is formed by the junction of the Blackwater and Nottoway rivers, nearly on the line between North Carolina and Virginia, whence it flows nearly south into Albemarle sound, between Hertford and Bertie counties on its right and Gates and Chowan on its left, entering the sound at its western extremity. It is navigable for its whole length—about 38 miles in a straight line, and perhaps 60 by the river. Its total drainage area is about 4,870 square miles, and its principal tributary is the Meherrin, which enters from the west. It flows, with a sluggish current, through a low and swampy country, entirely below the fall-line, with large portions subject to overflow at times, and possesses no water-power whatever, used or available. The principal town on the river is Winton, the county seat of Hertford county. The trade on the river is of considerable importance, large quantities of cotton, corn, wheat, tobacco, lumber, and fish being shipped.

THE MEHERRIN RIVER.

This stream is the most important tributary of the Chowan. It rises in Charlotte, Lunenburg, and Mecklenburg counties, Virginia, flows a little south of east, forming the boundary between Lunenburg and Mecklenburg counties; thence flows through Brunswick and Greenville, and between Greenville and Southampton counties, Virginia, and finally through Hertford county, North Carolina, emptying into the Chowan several miles above Winton. Its length, in a straight line, is about 100 miles, but is considerably greater by the river. It is navigable beyond the North Carolina line, a distance by the river of over 30 miles. The principal towns on the stream are Murfreesboro', North Carolina, about 15 miles from the mouth, and Hicksford, Virginia, about 50 or 60 miles from the mouth.

The drainage area of the Meherrin comprises about 1,675 square miles, about half of which lies below the fall-line, and in which the river is a sluggish stream, with a bed of clay or sand, and perhaps occasionally a ledge of rock. Its banks are subject to overflow, and the adjacent bottoms or low grounds are covered with extensive cypress swamps and pine woods. In this part of the river there is, of course, no water-power. Above the fall-line the country is not so level, the bed of the stream is more rocky, and the banks are not so subject to overflow, although there are still extensive low grounds which are flooded at times. The soil is sand and clay, and very fertile; the country well



DRAINAGE BASIN OF CHOWAN, AND ROANOKE RIVERS.

wooded, and the principal products are cotton, corn, wheat, tobacco, fruits, and vegetables. This part of the drainage-basin belongs geologically to the Eozoic formation, while that below the fall-line is Tertiary or later. The fall of the stream is nowhere very great, and the divides, separating its drainage-basin from the adjacent ones, are nowhere very high, so that the tributaries also have no very great fall. The latter, however, are small, and not of much importance, and I have only measured the drainage areas of a few of them. The results, together with the drainage areas above various points on the main stream, are given in the table on page 26.

The average rainfall on the drainage-basin of the Meherrin is about 44 inches, or a little less, of which about 11 fall in spring, 13 in summer, 8 in autumn, and 10 in winter. There are no lakes in the basin; neither are the facilities for the construction of storage reservoirs very good, the country being too flat.

The fall of the river in the last 30 miles of its course is not much over 1 foot to the mile, the elevation above mean tide of the mean water-surface of the stream at the crossing of the Seaboard and Roanoke railroad, some 30 miles from its mouth, being 31 feet.

According to an old survey by J. Williston, whose report is to be found in the twenty-second report of the board of public works of Virginia, the fall varies from 1 to 3 feet per mile.

In the entire absence of gaugings of the river its flow would have to be estimated, but I have made no estimate because of the small value of the stream as a source of power.

The water-power of the Meherrin and its tributaries is not of great importance. The flow of the stream is extremely variable, and no sites of importance were brought to my notice. Although the river crosses the fall-line in the vicinity of Lawrenceville or Hicksford, where we should expect to find a fall, I succeeded in obtaining no information regarding any power in that neighborhood. There seems to be no fall on either the Meherrin or the Nottoway at its crossing of the fall-line, although this line is very marked in the case of the Appomattox and the Roanoke. The river, however, is very inaccessible, especially above the fall-line—so much so that I did not consider it advisable to visit it at any point above—and it is therefore possible that there may be a power somewhere in this neighborhood. With the exception of the Petersburg railroad, which crosses the river near Hicksford nearly at right angles, no other railroad comes within 15 or 20 miles of the stream.

As to building materials, there is abundance of fine timber in all parts of the drainage-basin, and in some parts above the fall-line granite and similar rocks may be found.

The country is sparsely settled, and the people have given very little attention to the subject of water-power, so that little satisfactory information could be obtained with the time at disposal. The power utilized on the stream will be found tabulated from the reports of the enumerators, on page 27.

THE BLACKWATER RIVER.

This stream rises in Prince George county, Virginia, flows in a direction rather east of south between Surry, Isle of Wight, and Nansemond counties on its left, and Sussex and Southampton on its right, joining the Nottoway, on the North Carolina line, to form the Chowan; its length in a straight line being about 55 miles. It is navigable to the town of Franklin, the head of tide-water,* on the Seaboard and Roanoke railroad, about 13 miles from the mouth of the river. It drains an area of about 700 square miles, lying entirely below the fall-line, and possessing little water-power. The river is sluggish and tortuous, flowing mostly through cypress swamps with dense undergrowth, its width varying below Franklin from 100 to 275 feet, and its depth from 8 to 38 feet. Large areas are flooded at high water, although the extreme rise is not over 3 or 4 feet.* The fall of the stream for 22 miles above Franklin is not over 1½ or 2 feet to the mile, and for the next 7 or 8 miles only very slightly greater.† The elevation of the stream at the crossing of the Atlantic, Mississippi and Ohio railroad, about 15 miles above Franklin, is about 17½ feet above mean tide at Norfolk.‡ According to an old survey,§ the divide between the Blackwater and the Nansemond, which flows into the James, is nowhere more than 83 feet above tide.

The rainfall on the drainage-basin of the Blackwater is the same, and similarly distributed, as on that of the Meherrin. Estimates of flow are not necessary, on account of the absence of water-power on the river.

The river is accessible from stations on the Seaboard and Roanoke and the Atlantic, Mississippi and Ohio railroads, the latter of which follows the river for some 35 miles at a distance from it of only 3 or 4 miles.

THE NOTTOWAY RIVER.

This river rises in Prince Edward, Lunenburg, and Nottoway counties, Virginia, and flows in a general direction nearly southeast through a very fertile country, forming first the boundary between Nottoway and Dinwiddie counties on its left and Lunenburg and Brunswick on its right, thence flowing through Sussex and Southampton, joining the Blackwater, on the North Carolina line, to form the Chowan. The principal town on the stream is Jerusalem, Virginia. The length of the stream, in a straight line, is about 90 miles, and probably over 125 if its windings are followed. The table on page 26 gives particulars regarding drainage areas, the total area drained being about 1,650

* Annual reports Chief of Engineers, 1879, appendix G 12, p. 620; 1878, appendix G 12, p. 522; 1875, p. 161.

† Old survey, in one of the reports of the board of public works of Virginia.

‡ For the elevations on the Atlantic, Mississippi and Ohio railroad I am indebted to Mr. Hunter, of Petersburg, engineer of the road.

§ In the twenty-second report of the board of public works of Virginia.

square miles, divided nearly in two equal parts by the fall-line. The head of tide-water is at the crossing of the Seaboard and Roanoke railroad at Nottoway, some 12 miles from the mouth of the stream.* The tributaries of the Nottoway are not of much consequence, the principal ones being Assamoosick, Rowanty, Stony, and Little Nottoway creeks from the north and east, and Three creek and Waqua creek from the south and west. It is noticeable here, as elsewhere, that the principal tributaries enter from the northern side of the water-shed, a fact already referred to.

The Nottoway is now being improved by the government, the present project having in view the securing a navigable depth of 4 or 5 feet during nine months of the year as high as Peter's bridge, something over 50 miles above the mouth of the stream, and 20 miles above the town of Jerusalem. Five thousand dollars have been appropriated for the work, and the principal obstructions to navigation, which consist of snags, sunken logs, and overhanging trees, are being removed. It is expected that at low water a navigable depth of 2 or 3 feet will be secured as high as Peter's bridge, and of 7 or 8 feet as high as Monroe's ferry, about 15 miles from the mouth of the river, measured along its course. The drainage areas of some of these tributaries are given in the table of statistics. The principal products of the country drained by the Nottoway are cotton, corn, peanuts, tobacco, and wheat. As in the case of the Meherrin, I heard of no power on the Nottoway at the point where it crosses the fall-line. But in one of the reports of the board of public works of Virginia I found an account of a survey of the river, in which "the Great falls, on the south prong", were mentioned, situated 9¾ miles above the mouth of the Little Nottoway; and it was stated that the river there was 37 feet wide, with an average depth, at low water, of 23 inches, discharging 31 cubic feet per second. I did not consider it worth while to visit so small a power. The drainage-basin of the Nottoway is similar in all respects to that of the Meherrin as far as I could learn, so that it need not be described. The rainfall is also about the same; estimates of the flow are not necessary. No gaugings could be found for this river except the one mentioned above.

There are no lakes on the stream, and not very good facilities for reservoirs. The bed is in some places rock, but generally sand, gravel, and clay. Below the crossing of the Petersburg railroad the river has an average width of about 68 feet, with banks 10 or 15 feet high, and a bed of coarse gravel, and occasionally sand, loosely deposited on a friable sandstone.† On the lower part there are considerable areas of low ground, sometimes overflowed. According to an old report, the stream is 30 to 40 feet wide and 16 inches deep at low water for 10 miles above the mouth of the Little Nottoway; the current is gentle and the bed sandy. The Nottoway is more accessible than the Meherrin, being nearer to the Atlantic, Mississippi and Ohio railroad, the nearest road on the north.

I did not visit any sites or mills on the river, having been informed that they were unimportant. The same report which mentioned the falls on the south prong referred also to a power at "Spencer's mill", where there was said to be a fall of 12 to 15 feet; but I was unable to learn more particulars regarding this place, and did not consider it worth while to devote much time to searching for it. The country is sparsely settled, and the people have given little attention to water-power, so that without a personal examination of the river little satisfactory information could be obtained.

The tributaries of the Nottoway have some power, as is shown by the statistical table, but it will be seen that the only mills in this vicinity are grist- and saw-mills. There is no further manufacturing of any kind by water-power in the drainage-basin of the Chowan.

From what has been said, it seems that the tributaries of the Chowan offer little water-power, and are not, as a rule, favorable streams for manufacturing. The facilities for storage are small, the flow is variable, on account of the large evaporation, and the bed and banks are not very favorable for dams. There is, of course, some power available, but it is, according to all accounts, not very considerable.

Table of drainage areas of the Chowan river and tributaries.

River and place.	Drainage area.
	Square miles.
Chowan, at mouth	4,870
Meherrin, at lower edge of Lunenburg county	376
Meherrin, at lower edge of Brunswick county	671
Meherrin, at lower edge of Greenville county	1,070
Meherrin, at mouth	1,675
Fontaine's creek, at mouth (tributary of Meherrin)	288
North Meherrin, at mouth (tributary of Meherrin)	100
Middle Meherrin, at mouth (tributary of Meherrin)	35
South Meherrin, at mouth (tributary of Meherrin)	84
Blackwater, at mouth	700
Nottoway, at lower edge of Nottoway county	280
Nottoway, at lower edge of Dinwiddie county	475
Nottoway, at mouth of Rowanty creek	800
Nottoway, at lower edge of Sussex county	1,080
Nottoway, at mouth	1,650
Rowanty creek, at mouth (tributary of Nottoway)	125
Stony creek, at mouth (tributary of Nottoway)	210

*For the elevations of streams crossed by the Seaboard and Roanoke railroad I am indebted to the president, Mr. John M. Robinson.

†Twenty-first report board of public works of Virginia; report on survey by John Williston.

Table of utilized power of the Chowan river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total h. p. used.	Wheel.
						Feet.		
Chowan	Albemarle sound				0	0	0	....
Meherrin river	Chowan	North Carolina	Northampton	Saw	1	9	12	....
	Do	Virginia	Southampton	Flour and grist	1	5	10	....
	Do	...do	Greenville	...do	3	31	64	....
	Do	...do	...do	Cotton-gin	2	21	12	....
	Do	...do	Brunswick	Flour and grist	3	20	65	....
	Do	...do	Mecklenburg	...do	4	35	78	....
	Do	...do	...do	Saw	1	12	22	....
	Do	...do	Lunenburg	...do	1	16	19	....
Tributaries to	Meherrin	North Carolina	Hertford	Flour and grist	3	....	57	....
	Do	...do	Northampton	...do	6	30	70	....
	Do	...do	...do	Saw	2	8	16	....
	Do	Virginia	Southampton	Flour and grist	2	17	14	....
	Do	...do	Greenville	...do	6	57	83	....
	Do	...do	...do	Cotton-gin	3	28	35	....
	Do	...do	...do	Foundry	1	10	15	....
	Do	...do	Brunswick	Flour and grist	9	133	128	....
	Do	...do	...do	Saw	2	31	17	....
	Do	...do	Mecklenburg	Flour and grist	1	30	12	....
	Do	...do	Lunenburg	...do	5	122	150	....
	Do	...do	...do	Saw	2	37	85	....
Blackwater river	Chowan	Virginia	Surry	Flour and grist	1	8	8	....
Tributaries to	Blackwater	...do	Nansemond	...do	6	59	76	....
	Do	...do	...do	Saw	1	10	25	....
	Do	...do	Southampton	Flour and grist	7	82	133	....
	Do	...do	Isle of Wight	...do	3	11½	39	....
	Do	...do	...do	Saw	3	15½	55	....
	Do	...do	Surry	Flour and grist	2	16	18	....
Nottoway river	Chowan	...do	Southampton	...do	3	23	46	....
	Do	...do	Greenville	...do	1	9	8	....
	Do	...do	Dinwiddie	...do	2	21	42	....
	Do	...do	Nottoway	...do	1	26	20	....
	Do	...do	...do	Saw	1	26	20	....
	Do	...do	Prince Edward	...do	1	23	6	....
	Do	...do	...do	Flour and grist	1	23	6	....
Tributaries of	Nottoway	...do	Southampton	...do	4	45	83	....
	Do	...do	...do	Cotton-gin	3	....	17	....
	Do	...do	Sussex	Flour and grist	8	67	165	....
	Do	...do	Dinwiddie	...do	3	32	47	....
	Do	...do	...do	Saw	1	2	7	....
	Do	...do	Brunswick	Flour and grist	6	64	58	....
	Do	...do	Lunenburg	...do	1	20	10	....
	Do	...do	Nottoway	...do	3	66	27	....
	Do	...do	...do	Saw	2	49	15	....
	Chowan	North Carolina	Chowan	Flour and grist	1	7	8	....
	Do	...do	Gates	...do	2	18	71	....
	Do	...do	...do	Saw	1	9	30	....

II.—THE ROANOKE RIVER AND TRIBUTARIES.

THE ROANOKE RIVER.

This river is formed by the confluence of the Dan and Staunton rivers, in Mecklenburg county, Virginia. Thence flowing southeast, it enters North Carolina in Warren county, and forms the dividing line between Halifax and Martin counties on its right, and Northampton and Bertie on its left, emptying into Albemarle sound just above Plymouth. The total length of the river is about 125 miles in a straight line, and probably nearly twice as far by the river. The principal towns on the stream are: Clarksville, Virginia (just below the junction of the Dan with the Staunton), Weldon, Halifax, Hamilton, Williamston, and Plymouth, North Carolina. The stream is navigable at low-water to Weldon (some 120 miles), or can be made so for boats drawing 2 or 3 feet, and to Hamilton (60 miles) for boats drawing 10 feet. Boats of greater draught cannot come through the sound. It is considered possible to get a low-water navigation of 5 feet to Weldon,* the principal obstacles to navigation being snags,

* Annual Reports Chief of Engineers, 1872, p. 726; 1879, p. 624.

stumps, and sand-bars. By a system of locks and dams this river, with the Dan, was long ago made navigable to Danville, more than twice as far from the mouth as Weldon, but these old canal-works have been long in disuse, although the company which built them—the Roanoke Navigation Company—has continued in existence down to the present time. Although Weldon is now the head of navigation, yet there are still long reaches on the Roanoke and on the Dan, both above and below Danville, which are boatable.

The total area drained by the Roanoke river comprises about 9,200 square miles, of which the Dan drains 3,700, the Staunton 3,450, and the Roanoke below the junction 2,050. There are no large tributaries of the Roanoke below the confluence of the Dan and Staunton, although a number of small creeks flow into it from both sides.

The drainage-basin of the Roanoke proper is divided into two nearly equal parts by the fall-line, which crosses the river between Weldon and Gaston, North Carolina. That part of the water-shed below Weldon is low and flat, and partakes of the general characteristics of the eastern division, and therefore need not be described here in great detail. Above Weldon the country is more broken and the river has more fall, having cut its bed down to the underlying metamorphic rocks. The drainage-basin is long and narrow, varying in width from 10 to 30 miles, and along the river are many fine bottoms, among which are some of the best farming-lands in the vicinity. The bottoms widen out as we descend the river, and the flood-plain spreads out in places to a width of several miles, and finally is represented by the broad lowlands and cypress swamps of the eastern division. Alternating with the bottoms are bluffs, especially on the south side of the river. The proportion of the drainage-basin covered with forests I have not been able to ascertain. The soil is clay and loam, with sand in the lower part of the basin, and the productions are tobacco, corn, wheat, fruits, and vegetables. Below Weldon the country is heavily timbered, and large quantities of timber and shingles are shipped. It is said that between 15,000,000 and 20,000,000 shingles are made and shipped annually from this region. Above Weldon fine building-stone is found in many places, and in Granville, Warren, Edgecomb, and Wilson counties, North Carolina, a fine quality of granite is quarried. Near Gaston there is a deposit of specular iron-ore, which has been very little worked. The basin is thinly settled above Weldon, and the river is quite inaccessible, as will be seen from the map. The Raleigh and Gaston railroad, after leaving the river at Gaston, recedes rapidly from it, and afterward comes nowhere within 8 or 10 miles of it; while on the north the nearest railroads, the Richmond and Danville and the Atlantic, Mississippi and Ohio, are, on an average, 35 miles distant. Before the war Clarksville had railroad connection with the Raleigh and Gaston road, and was a thriving tobacco mart, but the road was torn up during the war to repair other roads, and has never been rebuilt,* in consequence of which the town has decreased considerably in population.

The average rainfall on the water-shed of the Roanoke above the fall-line is probably 40 or 42 inches, varying from 38 or 39 on the upper part of the Staunton to 44 inches at Gaston. Of this amount 10 or 11 inches fall in spring, about 10 inches in summer, and nearly the same in autumn and winter. Being so uniformly distributed, the flow of the stream may be expected to be very variable, especially as in all probability the evaporation is quite large; and, in fact, the general testimony is that the flow of the stream is subject to very large variations.

The freshets on the river are very violent and the fluctuations often occur very rapidly. At Weldon an ordinary freshet gives a rise of 12 or 15 feet; but generally twice in the year, in the spring and in the fall, there is a larger freshet, the water rising 25 to 30 feet. In 1865 the river rose 50 feet at that point, and 30 feet at Hamilton. For 60 or 70 miles below Weldon the rise is from 20 to 50 feet, but it gradually diminishes as the mouth of the river is approached, and for the last 15 or 20 miles of its course it is from 1 to 3 feet.† These floods occur so rapidly that the river rises sometimes over 10 feet in a day at Weldon,‡ and of course they overflow the banks and flood large areas of the adjoining lands.

There are no lakes or artificial reservoirs anywhere in the drainage-basin, neither are there facilities for storage on the Roanoke proper; but on the upper Dan and Staunton reservoirs might doubtless be constructed at many points.

The bed of the stream is generally sand below Weldon, with one or two ledges, and the banks are alluvial, not very low as a rule, and in many places lined with overhanging trees; while above Weldon the bed is generally composed of solid rock, sometimes of gravel and sometimes of sand or clay, the banks being alternately high and sometimes bluffy and low and alluvial. Above the falls at Weldon, which extend for a distance of 10 miles above that place, the river is wide, full of rocks and islands in many places, and difficult to navigate in low-water, with large areas of bottom-land subject to overflow in freshets, although the rise is smaller than at Weldon. Some of the low grounds were diked before the war, but the dikes have for a long time received no attention. High dams on the river would, in general, be accompanied by the overflowing of large areas.

* Annual Report of the Chief of Engineers, 1880, p. 803.
† Annual Report of the Chief of Engineers, 1872, p. 726.
‡ Annual Report of the Chief of Engineers, 1876, Appendix G, 9.

The following table will give some idea of the fall of the stream:

Table of declivity—Roanoke river.

Place.	Distance from mouth.	Elevation above tide.	Dist. between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Mouth	0	0	120	44	0.36
Weldon	120	44	9	84	9.3
Head of falls	129	128	56	141	2.52
Clarksville	185	269			

In the twenty-second report of the board of public works of Virginia is a report on a survey of the Roanoke, by J. J. Couty. It is there stated that the fall from Rock Landing, in North Carolina, to the confluence of the Dan and Staunton, in Virginia, is 156.65 feet, the distance being 59.9 miles. The same report states that the width of the river is considerable, being even three-fourths of a mile in places, but on the average about 400 yards, and that the bed is mostly of solid rock, and remarkably favorable for dams.

The *water-powers* on the stream will now be described as far as I have been able to obtain information regarding them.

The water-power at Weldon, North Carolina.—The first power on the river as it is ascended is that at Weldon, North Carolina, where the stream crosses the fall-line. The fall here is about 84 feet in a distance of 9 miles above the town, the river within this distance being very rocky and rapid, the channel very tortuous, and the bed of the river interspersed with rocks and islands, most of which are submerged at high water. Some of the larger islands are cultivated. The bed of the river is almost solid rock, and the banks generally abrupt, especially on the upper part, for several miles below the head of the falls, where they are 40 or 50 feet high, of hard granitic rock, and generally extending almost perpendicularly to the water's edge. The river is much narrower here than above the falls. Some fifty years ago the Roanoke Navigation Company extended navigation around these falls by constructing a canal on the south side of the river between Weldon and Rock Landing, 9 miles above. This canal was 30 feet wide at the top and 3 feet deep, dimensions sufficiently large for the boats then in use on the river. The enterprise does not seem to have been a financial success, and, although the company is still in existence, the works have long been allowed to fall into disuse, and the canal is very much filled up with silt and rubbish, being only kept clean to an extent sufficient to enable it to supply the necessary water to run a few small mills, no one but the mill-owners seeming to take any interest in it. It was originally substantially built, and crosses several small creeks by means of stone aqueducts, all of which, as well as some of the locks, which were also of stone, are in good condition, although the gates of the latter are gone; and toward the upper end of the canal there are extensive masonry walls in places on the river side, rendered necessary by the abruptness of the banks, and all in good condition. At the upper end of the canal there was a guard-lock, and probably a dam, but the gates of the lock are gone, and the dam now there consists only of a few stones piled up roughly. The river at this place is said to be very favorable for the construction of a dam which might extend entirely across the river.

Nearly four miles below the head of the canal is a flight of four locks with a total lift of 36 feet.* The fall of the upper two is utilized by a saw- and grist-mill and cotton-gin, using about 18 feet fall, 25 horse-power, and discharging the water to the lower level. This mill can run at full capacity all the time, but little additional power can be obtained without increasing the capacity of the canal above, which is at present only 12 to 15 feet wide and 3 or 4 feet deep. The total fall of these locks, 36 feet, is practically available at this place, and the land in the vicinity is favorable for building.

At the lower end of the canal a fall of 48 feet between the level of the canal and the river was overcome by a flight of 6 locks with 8 feet lift each.* This fall is used by two mills and a foundry; the upper one, a grist- and flour-mill (two run of stones) and two cotton-gins, uses 18 feet fall and 30 or 40 horse-power; the lower one, a corn- and flour-mill (six run of stones), uses the same fall and 70 or 80 horse-power, and the foundry uses the same fall and some 15 or 20 horse-power. All these mills discharge the water directly to the river, and are situated from 100 to 200 yards above the old locks, which are in bad condition. They can run full capacity all the year, except occasionally for a few days at a time, when they have to stop on account of high water. Little additional power, however, can be obtained with the present condition of the canal. There is scarcely any trouble whatever with ice.

Although the fall between the level of the canal at its lower end and the river is 48 feet at low-water, according to the report of the company the freshets of the river are so frequent and so violent that it is not to be considered practically available for manufacturing unless supplementary steam-power be introduced. Just what fall may be economically used depends on various circumstances which cannot be considered here. The land is favorable for building so far as its topography is concerned. The canal is at present somewhat wider on the lower level than on the upper, but is shallower.

* Report of Roanoke Navigation Company in one of the reports of the board of public works of Virginia.

As already mentioned, the canal at Weldon is owned by the Roanoke Navigation Company—a stock company, of which some shares are said to be owned by private individuals and some by the states of Virginia and North Carolina. There being no interest taken in the canal, either as a means of navigating the river or as a means of supplying water-power—it being, in fact, practically abandoned—the mills pay no rent for their water-power. It is said, however, that many years ago some water-power was let at a certain rate per runof stone.

In addition to the power which is utilized along the canal there is a small amount of power used between Weldon and Gaston by mills located directly on the river. Thus, on the north side of the river, there is a grist-mill with a fall of about 7 or 8 feet, running two or three run of stones, and there have been others, at various times, on both sides of the river. On the south side there was a grist-mill, about 1 mile below South Gaston, said to have had a fall of 15 feet, with a race one-half mile long. These mills are, of course, liable to be stopped often during freshets.

The total drainage area of the Roanoke above Gaston, or the head of the falls, is about 8,200 square miles, and the rainfall over this area is about 40 or 42 inches, distributed tolerably evenly throughout the year. I found no records of continued gaugings of the river. Professor Kerr measured the flow at Haskins' Ferry, over 50 miles above Weldon, in the fall, and found it to be 2,950 cubic feet per second, the drainage area above this point being about 7,350 square miles, but the stage of the river is not stated.* I have estimated the flow of the river at Gaston to be as follows (see pages 18 to 21):

	Cubic feet per second.
Minimum flow	1,500
Minimum low-season flow	1,700
Maximum available, with storage	6,000
Low-season flow, dry years	1,950

The corresponding power may be tabulated as follows:

Flow, cubic feet per second.	Horse-power available, gross.			
	1 foot fall.	36 feet fall.	18 feet fall.	84 feet fall.
1,500	170	6,120	3,060	14,280
1,700	193	6,948	3,474	16,212
6,000	680	24,480	12,240	57,120
1,950	221	7,956	3,978	18,564

If the water could be stored during the night, so as to concentrate the total available power into 12 hours, the powers given in the table above would all be doubled, but it would probably be found very difficult and expensive, if not impossible, to do this. The estimates I have given may seem too low, but I have been especially anxious to avoid making them too high, and I believe that they will be found rather under than over the truth. This enormous power, almost totally unutilized, is available, although it would be very expensive to utilize the whole of it. The existing canal, if cleaned out to its original dimensions, would be capable of carrying about 120 cubic feet per second, with a fall of a foot to the mile, and by making the channel *very smooth* it might carry 250 to 300 cubic feet per second with the same dimensions. To enlarge the canal to the dimensions necessary to enable it to carry 1,500 cubic feet per second would, especially in the upper part, be very expensive, and necessitate considerable blasting. The power which would be rendered available if the canal were cleaned out to its original dimensions is shown by the following table, the fall assumed being one foot to the mile. The capacity may be taken to vary between 120 and 250 cubic feet per second, according to the condition of the bed:

Table showing available power at Weldon with existing canal.

Capacity of canal, cubic feet per second.	Horse-power available, gross.			
	1 foot fall.	36 feet fall.	18 feet fall.	84 feet fall.
120	13.64	491.0	245.5	1,145.8
250	28.41	1,022.8	511.4	2,386.4

The power is calculated for the same fall as before, because the fall of the canal itself could be given by a dam at its head. It must be expressly remarked that if the capacity of the canal is to be made 250 cubic feet per second, the bed and slopes must be made very smooth, indeed, by being cemented or lined with boards carefully fitted to each other, and with great care the capacity might, perhaps, be increased above 250 cubic feet per second. If the fall is made 2 feet per mile, the available powers would be nearly 1.4 times as great as those given in the above table. By deepening the canal its capacity might be considerably increased at small cost.

* Maury (Survey of Virginia, pp. 36, 37,) says that the flow of the Roanoke at head of tide-water in dry seasons is *estimated* at 1,350 cubic feet per second.

The powers given in the above table could be rendered available without much difficulty, but it must be remembered that all the power calculated thus far is the gross horse-power, and that the amount to be practically utilized would be less, varying according to the motor employed. With good turbine-wheels the net power will be about three-quarters or eight-tenths of the gross power.

The power at Weldon is one of the largest in the state of North Carolina, and the principal cause of its not being utilized to a greater extent is probably the lack of capital. It is said that the place is not very healthy, and that malaria and chills and fever are prevalent at certain seasons. It is certain that it is not so healthy as the country farther west, but I doubt whether this would be a sufficient ground to prevent the utilization of such a magnificent power. The facilities for transport are excellent, both by land and by water, for the river can be made navigable up to the town, and it is quite a railroad center. Four railroads terminate in the town, viz, the Petersburg railroad, the Seaboard and Roanoke railroad, the Wilmington and Weldon railroad, and the Raleigh and Gaston railroad, thus bringing Weldon within 2½ hours of Petersburg, 3½ hours of Richmond and Portsmouth, 6 hours of Wilmington, and 5 hours of Raleigh.

Good building-stone and timber can be obtained in abundance in the neighborhood, and a good deal of cotton is raised in the vicinity. The iron-deposits near Gaston have only been worked to a very small extent, although the ore is said to be of good quality. The advantages for the utilization of the power are in fact excellent in all respects, and that there are no serious drawbacks is proved conclusively by the successful operation of Mr. Battle's cotton factory at Rocky Mount, on the Tar river, only a few miles distant. The place is worthy of a careful examination by capitalists.

Above Gaston the river widens, and there are no other powers at all comparable with the one just described, although there are some shoals which might advantageously be utilized, alternating with long boatable stretches of smooth water. In regard to these shoals, however, I was only able to obtain a few scattered notes, and on account of their inaccessibility I was unable to visit any of them.

Four miles above Rock Landing, the head of the Weldon canal, is a shoal, around which the Navigation Company constructed a canal 400 yards long, with a lock at the lower end having a lift of 9 feet. The fall at this shoal is said to be utilized, to a small extent, by a grist-mill.

Two miles further up there is a second mill, and above that are several others, tabulated in the table of utilized power. The available fall, however, I am unable to state. The only other place on the river where the Navigation Company found it necessary to construct a canal was at Pugh's falls, where there was one lock with 5½ feet lift,* but I am unable to say just where this place is located. I am also unable to give any information regarding the present condition of these canals, but the probability is that they are in very bad order.

The principal reason why these shoals have not been used more extensively is probably the fact that the river is wide, so that the dams necessary are long and expensive and subject to injury by the freshets. Of necessity, therefore, mills have usually been located on smaller streams.

Finally, it may not be out of place to say a few words regarding the causes of the low flow of the Roanoke (estimated), as compared with that of streams in New England. These causes are probably the following: (1) The rainfall on the drainage-basin is not greater, and probably rather less, than on the basins of New England streams; (2) it is, on the whole, tolerably uniformly distributed throughout the year, but on some parts of the Dan and Staunton rather more falls in winter than in summer; hence, as the evaporation is very large, the streams will be very low in summer, when the evaporation is greatest and the rainfall least; (3) there are no lakes to regulate the flow.

As regards the estimate which I have given for the power available at Weldon, with storage, it is to be remarked that to render this power available would require the construction of storage-reservoirs sufficient to store a rainfall of perhaps 3 inches on the whole water-shed, which would correspond to a storage capacity of over 57,000 millions cubic feet. Such storage would be very expensive, so that, for the present at least, the estimate of power from storage has little interest practically.

TRIBUTARIES OF THE ROANOKE RIVER BELOW THE JUNCTION OF THE DAN AND THE STAUNTON RIVERS.

In regard to these streams very little is to be said. None of them are of any importance, and possess no large water-powers, so far as I could learn. The only power used on them is for running small grist- and saw-mills, the grist-mills generally with one, two, or three run of stones. I visited none of these streams, and the tables of the power utilized on them, compiled from the reports of the enumerators, will show that they are not of much consequence. For small powers they can be economically utilized—more economically than the Roanoke itself—because they have more fall, because the cost of a permanent dam is less, and because the mills are not troubled with high water, as those on the Roanoke are; but their flow is, of course, much more variable than that of the Roanoke.

*Report of Roanoke Navigation Company in one of the reports of the Virginia board of public works.

THE DAN RIVER.

The Dan river, one of the main forks of the Roanoke, rises in Patrick county, Virginia, near Buffalo Knob, in the Blue Ridge. It flows first in a southeasterly direction, enters North Carolina, flows through Stokes and Rockingham counties, and, pursuing a general easterly course, enters Virginia in Pittsylvania, returns to North Carolina in Caswell, and finally enters Virginia again in Halifax, to unite with the Staunton in the adjoining county of Mecklenburg, forming the Roanoke. The length of the stream, measured in a straight line nearly east and west, is about 100 miles, and by the course of the river about 180 miles. The principal towns on the river are Danbury, Madison, and Leaksville, North Carolina (all small towns of several hundred inhabitants); Danville, Virginia, with a population of over 13,000; Milton, North Carolina, and South Boston, Virginia, with five or six hundred inhabitants each.

As has already been stated, the river was many years ago made navigable by the Roanoke Navigation Company as far as Danville, and for 50 or 60 miles beyond. It is now navigable for 60 miles above that place (as far as Sauratown) for bateaux carrying 12,000 pounds, although formerly bateaux sometimes reached Hairston's falls, 12 miles below Danbury. Boats propelled by poles now ply irregularly between Danville and various other points on the river.

The river and harbor act of June 18, 1878, provided for a survey of the river from Clarksville, Virginia, to Danbury, North Carolina, and the reports on this survey by Mr. S. T. Abert, United States civil engineer, are to be found in the reports of the Chief of Engineers, 1879, p. 652, and 1880, p. 794. These reports give detailed information regarding the river, and have been used freely in the present report. By the river and harbor act of June 14, 1880, the sum of $10,000 was appropriated for the improvement of the river between Madison, North Carolina, and Danville, Virginia, "the object being to afford a channel for steam navigation not less than 35 feet wide, and not less than 1½ feet deep in the pools and 2 feet deep in the rapids at extreme low-water," the estimated cost of the work being $52,000.

The total area drained by the Dan is 3,700 square miles. The tables on pages 34, 35, 37, and 38 give the drainage areas above the principal water-powers.

The principal tributaries to the river are, from the north, going up the river, Bannister river, Birch creek, Sandy river, Smith's river, and Mayo river; from the south, going up, Hyco river, County-line creek, Moon's creek, Hogan's creek, and Town fork. These will be referred to again.

The drainage area of the Dan lies principally in the middle division, the sources of the river being on the eastern slope of the Blue Ridge. Its general character does not differ, as a whole, from that of the middle division, which has been described on a previous page. Its shape and dimensions may be seen by referring to the accompanying map. Geologically, it lies in the area of metamorphic rocks. Granite is found at various points; also sandstone, limestone, and slate, and fine building-stone is to be had in abundance. The valley is rich in coal and iron, extensive beds of iron-ore, which have been worked to some extent for more than half a century,* occurring near Danbury, North Carolina. The coal-fields embrace an area of over 30 square miles, and have been developed only to a very small extent. Lying in the immediate vicinity of extensive iron-beds, their importance cannot be overestimated.† Copper also has been found in the valley.

The water-shed separating the valley of the Dan from those of the Yadkin and Cape Fear is a "long and broad ridge or swell of land, which trends due east", with an elevation of 800 feet and upward. The bed of the river is generally 200 or 300, and sometimes 400, feet below the adjacent ridges, and its tributaries have, therefore, very considerable fall, some of them affording very fine water-power.

The principal products of the valley are tobacco, corn, wheat, rye, oats, potatoes, and fruits. There is very little, if any, cotton grown in the valley. "Between Danbury and Leaksville the land appears to be best adapted to tobacco culture, and a fine grade is produced, although there are some short stretches of very good bottom-land. Further down, the valley widens, and broad bottoms are found cultivated in corn and wheat." The country is hilly and undulating, and in the extreme west mountainous. The forests above Danville are extensive and valuable.

There are no lakes in the basin, but artificial storage-reservoirs could probably be located at many points.

The bed of the river is solid rock, overlaid between the rapids with sand and gravel. The facilities for dams are excellent. Above Danville the banks are generally moderately high, and sometimes abrupt and bluffy, and the bottoms narrow and not often overflowed. Below Danville the banks are lower, the bottoms wider, and oftener overflowed, and bluffs more rare. There are no regular ravines of any extent, a bluff on one side of the river being generally faced by shelving or low ground on the other.

The river is subject to heavy floods, the river rising and falling very rapidly. At Madison, in 1850, it rose 28.4 feet; and at Danville, in 1873, 17 feet above ordinary low water. Below Danville the floods rise still higher. Thus, in November, 1877, the river rose to heights of 30.21 feet above low water at Milton; 33.54 feet at Oliver's mill, 28 miles below Danville; and 23.7 feet at Clarksville. Such rises are, however, very rare. There is seldom any trouble with ice, and ice-jams occur very seldom, although the river is sometimes frozen over. "Notwithstanding the height of the floods, the banks are seldom washed, their permanency being secured by a fringe of willow-growth, which borders the low grounds."

* Annual Report Chief of Engineers, 1879, p. 654.

† Dr. Genth (see above source).

The Dan and Staunton rivers, being comparatively not so wide or shallow as the Roanoke, and having fewer bottoms subject to overflow, are considered more favorable for navigation than the latter stream.

The average annual rainfall on the valley of the Dan is about 43 inches, distributed approximately as follows: Spring, 11; summer, 12; autumn, 10; winter, 10. In the upper parts of the valley the rainfall is as follows: Spring, 12; summer, 14; autumn, 10; winter, 14 inches. The following table will show the declivity of the stream:

Table of declivity—Dan river.

Place.	Distance from mouth.	Elevation above tide.	Dist. between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Clarksville	0.00	269			
			64.27	121	1.88
Danville, Richmond and Danville railroad-crossing*	64.27	390			
			50.10	157	3.13
Madison bridge	114.37	547			
			14.94	52	3.49
Hairston's ford	129.31	599			
			13.45	95	7.26
Danbury ford	142.76	695			

* For the elevations on the Richmond and Danville railroad I am indebted to T. M. R. Talcott, general manager, who had special measurements made of the height of the track above the water-surface.

Having no records of gaugings of the Dan river, I am obliged to resort to estimates of the flow. The following estimates are for the mouth of the stream:

Table of estimated flow and power of the Dan River at mouth.

State of flow (see pages 18 to 21).	Drainage area.	Flow per second.	Horse-power available, gross.
	Sq. miles.	*Cubic feet.*	*Per foot fall.*
Minimum	3,700	700	80
Minimum low season	3,700	810	92
Maximum, with storage	3,700	3,000	341
Low season, dry years	3,700	950	108

The Dan river has been thus far not very accessible above Danville. Below that point the Richmond and Danville railroad is within 4 miles of the stream for about 50 miles, after which it leaves the river nearly at right angles. Above Danville the river is for about 30 miles within 6 miles of the railroad, but above that it has been quite inaccessible. Thus the part of the stream which is easily accessible is between the mouth of the Bannister river and the town of Leaksville. Two railroads are now being built, however, which will render that part of the river above Danville as accessible as that below, and will do a great deal to develop the resources of the valley (see page 36).

WATER-POWERS.—It has already been stated that the average fall of the Dan between Clarksville and the Richmond and Danville railroad bridge is 1.88 feet per mile. This fall is, however, not evenly distributed over the whole distance, but is mainly concentrated at a few localities, thus affording fine opportunities for developing large water-powers.

In the table below is given each shoal on the river, but as some are of no importance, and their fall is very small, I do not consider it worth while to make mention of them particularly. I shall therefore mention in this place only the larger shoals, giving such of their characteristics as I have been able to gather from the reports of surveys made under direction of Mr. Abert. The falls given in the table are those of the shoals opposite which they are placed, and the distance of whose foot, from Clarksville, is given in the second column.

Proceeding up the river from Clarksville, the first shoal encountered is *Skipwith's shoal*, one-fourth of a mile above the town. Length of shoal, 6,660 feet; fall, 2.621 feet; rock bottom. Not utilized.

For the next 4 miles the fall is very gentle, and at one place the Staunton river is only 500 feet distant, a portion of the water of the Dan flowing over through what is called Skipwith's Thoroughfare to join the Staunton. About 5 miles from Clarksville is *Nelson's shoal*, a little over a mile long, with a fall of 2.216 feet; rock bottom; not used; river full of rocks, many appearing above the surface.

About 7½ miles above Clarksville is another channel, between the Dan and the Staunton, about 120 feet wide, one-half a mile long, and known as the Upper Thoroughfare. From this point down to their confluence the two rivers are nowhere more than three-fourths of a mile apart. Just above this thoroughfare commences *Marbleyard shoal*, 8,319 feet long; fall, 4.665 feet; rock bottom; not used.

The next shoal of importance is *Little Hyco falls*, a very dangerous shoal for boats, and one which is ascended with difficulty. The most important shoal on this part of the river is *Big Hyco falls*, 13 miles above Clarksville. The bed of the stream consists of a series of rock ledges and projecting rocks, over which the water rushes swiftly. I did not visit this place in person, but I was informed that the bank on one side is bluffy, while on the other a canal could easily be led out, if necessary. Then follow a series of smaller shoals. King's shoal is utilized for a small grist-mill, with an undershot wheel and a wing-dam, and Moon's shoal was formerly so used. It is noticeable that there are several steam saw-mills in this vicinity.

The *Yellow Gravel shoal* is used for power, running a grist-mill on the south side of the river, which is here divided by an island 3,300 feet long into two channels of nearly equal width. From the head of the island a dam extends diagonally across the left channel, having a length of 600 feet, and serving to turn the water into the right channel, on which the mill is situated, some 2,200 feet below, with a second dam 5.8 feet high across this channel. Nine-tenths of the volume of the river, however, pours through a sluice in the dam at the head of the island. The mill is driven by a 6-foot turbine-wheel, operating 3 run of stones, or using perhaps 40 net horse-power.* The river bottom at this shoal is generally gravel, with some rock. For over 7 miles above this place there is no shoal of importance, the next being *Reedy Bottom shoal*—a long shoal, with a pretty uniform slope, and generally a rock bottom.

At *Coldwell's shoal* is one of the dams built by the Roanoke Navigation Company, but the fall is not of importance. There are several saw-mills on the river between this shoal and the previous one, but none of importance.

The next shoal of importance is the *Milton shoal*. The fall is moderate in the upper 4,100 feet, but for the remainder of the length very rapid, and the river is full of islands and rocks. Below the shoal the river is only 120 feet wide for a distance of three-quarters of a mile.

The next shoal of importance is the *Danville shoal*, just below the Richmond and Danville railroad-bridge, and nothing more than a continuation, with a less rapid fall, of Danville falls, yet to be described. The bottom is wholly rock.

In regard to the amount of power which can be utilized on the river between Danville and Clarksville, an opinion could only be formed by a personal examination. From what has been said, it is clear that there would be no difficulty in building dams almost anywhere, so far as the bed of the stream is concerned, and the banks are much more favorable than on the Roanoke; but whether much of the fall is available for power, at reasonable cost, I cannot say. In the table are given estimates of the power at only a few points, but at the end are added estimates of the total theoretical powers between those particular points, but which are, probably, not practically available. The powers given for the separate shoals are for the natural fall in the river at each shoal, and may, of course, be increased if that fall is increased by a dam.

Summary of power, etc., of the Dan River between Clarksville and Danville.

Locality.	Distance from Clarksville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.†				Total utilized.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Fall.	Horse-power, net.	
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*					*Feet.*		
Skipwith's shoal	0.23	3,700	11	12	10	10	43	2.621	6,660	210	240	890	280	......	......	Rock bed.
Nelson's shoal	5.18	3,700	11	12	10	10	43	2.216	5,565	......	......	......	......	......	......	Do.
Jericho shoal	7.00	3,700	11	12	10	10	43	0.905	1,210	......	......	......	......	......	......	Do.
Marbleyard shoal	7.71	3,690	11	12	10	10	43	4.665	8,319	375	425	1,575	500	......	......	Do.
Hog island shoal	9.48	*3,680	11	12	10	10	43	1.261	882	......	......	......	......	......	......	Do.
Island creek shoal	9.93	*3,670	11	12	10	10	43	2.390	3,294	......	......	......	......	......	......	Do.
Bagby's shoal	10.65	*3,610	11	12	10	10	43	0.771	1,854	......	......	......	......	......	......	Do.
Hyco shoal	11.23	*3,600	11	12	10	10	43	1.957	3,560	......	......	......	......	......	......	Do.
Little Hyco falls	12.09	*3,600	11	12	10	10	43	3.100	1,510	240	275	1,075	315	......	......	Do.
Big Hyco falls	12.82	3,190	11	12	10	10	43	9.382	3,153	610	750	3,000	850	......	......	Do.
King's shoal	14.69	*3,180	11	12	10	10	43	2.670	4,482	......	......	......	......	2	20	Rock and gravel bed.
Grassy creek shoal	17.61	*2,670	11	12	10	10	43	1.478	2,926	......	......	......	......	......	......	Rock bed.
Moon's shoal	19.93	*2,650	12	12	10	11	45	2.331	1,406	......	......	......	......	......	......	Do.
Boston shoal	23.15	*2,620	12	12	10	11	45	2.131	2,858	......	......	......	......	......	......	Do.
Yellow Gravel shoal	28.20	*2,580	12	12	10	11	45	3.644	4,068	190	230	590	265	5	15	Drift, rock, and gravel bed.
Chappell's fish-trap	32.08	*2,540	12	12	10	11	45	0.986	280	......	......	......	......	......	......	Fish dam.
Lawson's shoal	33.08	*2,520	12	12	10	11	45	1.087	2,886	......	......	......	......	......	......	Drift and sand bed
Reedy Bottom shoal	34.20	2,485	12	12	10	11	45	5.223	11,338	265	320	1,250	365	......	......	Rock, gravel and sand bed.

* Interpolated. † See pages 18 to 21.

* The flow of the stream was measured by Mr. J. H. Gill, U. S. assistant engineer, just below this place, "at low-water," and found to be 990 cubic feet per second.

Summary of power, etc., of Dan River—Continued.

Locality.	Distance from Clarksville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross. †				Total utilized.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Fall.	Horse-power, net.	
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*					*Feet.*		
Powell's shoal	37.77	*2,460	12	12	10	11	45	1.241	4,478	......	......	......	......	......	......	Rock and sand.
Coldwell's shoal	43.52	*2,420	12	12	10	11	45	1.646	2,738	......	......	......	......	......	......	Gravel and rock.
Milton shoal	50.05	2,286	12	12	10	11	45	7.138	6,898	330	400	1,600	460	......	......	Rock.
Dodson's shoal	51.61	*2,270	12	12	10	11	45	2.384	1,204	......	......	......	......	......	......	Do.
Crowder's shoal	54.95	*2,240	12	12	10	11	45	1.379	3,290	......	......	......	......	......	......	Do.
Rattlesnake shoal	55.78	*2,230	12	12	10	11	45	1.174	3,202	......	......	......	......	......	......	Do.
Wilkinson's shoal	58.41	*2,200	12	12	10	11	45	0.979	720	......	......	......	......	......	......	Do.
Pass' shoal	58.80	*2,140	12	12	10	11	45	0.670	700	......	......	......	......	......	......	Do.
Dix's shoal	59.27	*2,130	12	12	10	11	45	1.714	282	......	......	......	......	......	......	Gravel.
Noble's shoal	60.38	*2,010	12	12	10	11	45	2.173	2,052	......	......	......	......	......	......	Rock.
Allen's shoal	61.28	*2,000	12	12	10	11	45	0.665	884	......	......	......	......	......	......	Do.
Jack Bar shoal	62.09	*1,990	12	13	10	12	47	1.890	854	......	......	......	......	......	......	Gravel.
Wilson's island shoal	62.27	*1,990	12	13	10	12	47	2.185	2,280	......	......	......	......	......	......	Rock.
Danville shoal	62.69	1,989	12	13	10	12	47	10.668	8,375	430	500	2,100	570	......	......	Do.
Richmond and Danville railroad bridge.	64.27	1,989	12	13	10	12	47	......	......	......	......	......	......	......	......	
									Miles.							
Between head of Skipwith's shoal and foot of Marbleyard shoal	1.49 7.71	3,700 3,690	11	12	10	10	43	6.452	6.22	515	590	2,200	675	......	......	
Between head of Marbleyard shoal and foot of Little Hyco shoal	9.29 12.09	3,690 3,600	11	12	10	10	43	7.272	2.80	565	650	2,550	740	......	......	
Between head of Big Hyco shoal and foot of Yellow Gravel shoal	13.42 28.20	3,190 2,580	12	12	10	11	45	15.274	14.78	820	990	3,950	1,130	......	......	
Between head of Yellow Gravel shoal and foot of Reedy Bottom shoal	28.96 34.20	2,580 2,485	12	12	10	11	45	6.076	5.24	315	385	1,500	440	......	......	
Between head of Reedy Bottom shoal and foot of Milton shoal	36.34 50.05	2,485 2,286	12	12	10	11	45	14.735	13.71	720	880	3,500	1,000	......	......	
Between head of Milton shoal and foot of Danville shoal	51.36 62.69	2,286 1,989	12	12	10	11	45	24.117	11.33	1,050	1,280	5,150	1,460	......	......	
Total on Dan river up to head of Danville shoal.	64.04	3,700 1,989	11	12	10	10	43	120.806	64.04	6,635	7,915	31,290	9,050	......	......	

* Interpolated. † See pages 18 to 21.

The next power above the Danville shoal is at *Danville falls*, at the city of Danville, Virginia. The total fall here is 21.977 feet, in a distance of 7,425 feet, between the Richmond and Danville railroad-bridge and a point 2,000 feet above the existing dam. The town of Danville is situated on the south side of the river, and on the opposite side is the village of North Danville. The bed of the stream is of solid rock, covered in places with sand and gravel, and the banks are shelving on the south side, offering good building-sites, while on the north side they are more abrupt and less favorable; and along this bank runs, for a short distance, the Virginia Midland railroad, which terminates at the Richmond and Danville railroad-bridge. Around these falls the Roanoke Navigation Company constructed a canal, on the south side of the river, about 3,200 feet long, 30 feet wide, and probably originally about 3 feet deep, with three locks at the lower end, having a total lift of 20¼ feet, and a guard-lock at the head with a lift of 7 feet.* The locks are out of repair, and no attempt is made to keep them in order, this canal having passed into the hands of private individuals, and being used only to supply water-power. It is said that none of the canals on the Roanoke or Dan rivers, except the one at Weldon, are now owned by the Navigation Company. The upper gate of the lower locks is kept closed to keep the water level up, and although boats enter the canal from above there is no egress below. At the head of the canal is a dam built of wood and stone—the wooden frame being bolted down to the rock with iron pins—extending in a broken line diagonally up stream, with a length of about 700 feet and a height of about 4 feet. The river here is about 1,100 feet wide, and the dam extends rather beyond the center. It was built about the year 1830, but the principal part was rebuilt in 1873 and 1874, and cost about $8 per running foot. It is founded entirely on solid rock, and, although once a little injured by a freshet, there is rarely any trouble with either freshets or ice. The pond is, of course, insignificant. The canal, although probably originally 3 feet deep, is at present much filled up in some places, its depth varying from 1.9 to 3.5 feet, and supplies power to the following mills, taking them in order down the canal:

1st. Gerst's planing-mill. A new mill is now being put up, and the old one is not running. They have a fall of 7 or 8 feet, and own the right to 50 horse-power, but no care is taken by those owning the power to regulate strictly the quantity of water they consume. They can run at their full capacity for about seven months, and sometimes can only get half capacity.

* Report of Roanoke Navigation Company in one of the reports of the board of public works of Virginia.

2d. Foundry and machine-shop, owned by Crews & Rodenhizer, and rented by Corbin & Westbrook. They only run two or three days of the week, use 9-feet fall and 30 horse-power, and say that they can get full capacity all the time. They use an overshot wheel, and the amount of water is not strictly regulated.

3d. G. W. Yarbrough's grist-mill, running two sets of stones, with 17 feet fall and some 25 horse-power. Full capacity can be obtained during nine months, and sometimes only one-half can be obtained. Mill and power is rented at a fixed price per annum, and as much water can be used as can be obtained, for here, as in the other cases, no attempt is made to regulate the amount. The water-power on this side of the river is owned by the firm of Crews & Rodenhizer.

These mills have no trouble with ice, and the upper one has none with backwater, but the lower two are troubled for perhaps two days in the year from that cause. All these mills could get full capacity all the time if the canal were properly cleaned out.

The power on the north side of the river is owned by Lee, Hatcher & Co., and is used for a corn- and grist-mill and a foundry and machine-shop. The dam, which is built partly of wood and partly of stone, extends, in a broken line, very obliquely up stream below the dam on the south side, and not reaching the center of the stream. The stone part extends from the bank for a distance of 400 feet, was built in 1874 at a cost of $5,000, and has an average height of 4 feet; while the wooden part, a continuation of the stone part, has a length of 600 feet, a height of 4 feet, and was built in 1876 at a cost of $2,000, being constructed of crib-work, fastened to the rock with iron pins, and filled with stone. The bed is solid rock. The mills are situated at the base of the dam, using a fall of 8 feet 2 inches, and about 80 horse-power, the tail-race being blasted out of the solid rock for some distance. The dam simply intercepts what water flows around the end of the Danville dam, and, of course, gives no storage. The owners claim 200 horse-power available with the fall mentioned, and expect to get full capacity all the time. (The improvements were in progress at the time of my visit.) The flour-mill has 4 sets of stones, and will run night and day, and the machine-shop 10 hours. Three turbine-wheels supply the power. The dam has never been carried away or injured by freshets. Mr. Hatcher states that, with a 5-foot dam further up the river, a fall of between 16 and 17 feet can be rendered available in a distance of 2,500 feet; and the firm indicated their intention of developing the power to a large extent in this way, and of leasing water at a fixed rate per day per horse-power.

The city of Danville obtains its water-supply by pumping water from the river at a point about 1½ miles above the dams. The present supply amounts to 2,000,000 gallons per week, but is expected to be 5,000,000 in a few years, as the water-works are new. This amount, however—less than 2 cubic feet per second—is insignificant as a source of loss of power below.

The width of the river opposite Danville varies from 1,100 feet, at the head of the falls, to 850 feet at other points. Between Danville and Milton shoal it is from 240 to 640 feet, or an average of 280 feet; at Milton shoal it is from 240 to 440 feet; from Milton shoal to Hyco shoal it is from 210 to 540 feet, or an average of 300 feet, and below Hyco shoal it is from 250 to 530 feet, or an average of 340 feet.

The area drained by the Dan above Danville is about 1,989 square miles, and the rainfall about 42 to 46 inches, with 13 inches in summer and 12 inches in winter (see table on page 37). In the absence of any gaugings of the flow, I have estimated it, and the power, as in the following table:

Estimate of flow of stream, and of the power, at Danville, Virginia.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*22 foot fall.*
Minimum	1,984	21.977	360	40.7	900
Minimum, low season			420	47.4	1,150
Maximum with storage			1,750	199.0	4,375
Low season, dry years			475	54.0	1,188

The full power at Danville has never been utilized. The present canal, if cleared out to its original dimensions (30 feet wide at top and 3 feet deep), would, as in the case of the Weldon canal, carry from 120 to 250 cubic feet per second, but in this case it would not be difficult to make its capacity sufficient to carry the whole flow of the river.

The question of the purchase by the city of Danville of the entire water-power of the Dan river at this place has been agitated recently.

Although the valley of the Dan above Danville offers sites for storage-reservoirs, yet it would, perhaps, be difficult to obtain sufficient storage to render the maximum power available.

The location of Danville, as regards transportation, is most favorable, situated as it is on the Richmond and Danville railroad, and on the Virginia Midland. Several new roads have been projected, and two are being built (or have been surveyed and located) up the valley of the Dan. One of them, the North Carolina Midland railroad, is to run from Danville through Madison, thence southward to Statesville and further. The termini of the other road I cannot state, but I understand that it is to run from Danville up the valley of the Dan. The staple product in this

neighborhood is tobacco, and the people have not turned their attention to manufacturing, except to a very small extent. The neighboring region is very salubrious, and there seems to be no reason why the water-power of the river should not be more extensively used.

Proceeding up the river, various shoals are encountered, all of which are mentioned in the following table. As before, the power has been calculated only for the principal ones. I am unable to describe in detail any of these shoals, not having visited any of them in person. It is evident, however, that the facilities for power are good, as far as bed and banks are concerned, both from Mr. Abert's report and from what additional information I could gather. The width of the stream between Danville and Madison varies from 190 to 430 feet, averaging perhaps 250 feet. At Hairston's ford, above Madison, it is 160, and at Danbury 120 feet. The power of the river is utilized between Danville and Danbury at only two points, viz, at Eagle falls and at Hairston's falls, and there only by small grist- and saw-mills, using a very small amount of power. The mill at Hairston falls is supplied by a dam at the head of the falls, extending in the form of a V across the stream, with the apex up stream, and constructed of logs. It was built in 1879, at a cost of about $125, and is about 150 yards (?) long and 3½ feet high, backing the water about half a mile. A race about 2,000 feet long leads to the mill, located on the right bank, where a fall of 9 feet is used with a primitive wheel to drive the grist- and saw-mill, some 20 horse-power (net) being utilized, and in dry weather no water flowing over the dam. The bed of the river is solid rock.

A power just above Danbury was formerly used to a small extent by the iron-works at that place. The dam was 10 feet high, and the water carried to the works through a tunnel about 100 yards long, cutting through a spur of the hills around which the river bends, and affording at the lower end of the canal a fall of 21 feet. The fall used by the works was about 16 feet, and the distance from the head of the canal to the foot of the tail-race about half a mile by the river. A very small proportion of the dry-weather flow of the stream was utilized. The works have not been in operation since 1865, and the dam has been entirely washed away. It is said that a dam 18 feet high could be built at this place, in which case the available fall, at the lower end of the canal, would be 29 feet.

Above Danbury the Dan is a small stream, but has a great deal of power, on account of its rapid fall. I can form no estimate of its available power, but it is safe to say that sites for small mills can be found at numerous points all the way up. The utilized power is tabulated below.

The results in the tables below must only be considered as very rough approximations, but I believe the powers given to be rather too small than too great. When it is remembered that the rainfall records for the region considered are very incomplete indeed, so that its distribution through the year is very uncertain, and that there are no gaugings of the river in existence, the engineer will be inclined to put little reliance on the figures given, and I must be distinctly understood as not claiming for them any more value than they are worth. A more accurate knowledge of the climatic and other features of the region considered would doubtless lead me to alter my estimates. And finally, it is to be remarked that these figures refer to the power available with the natural fall of the stream, with its natural flow; or, in the case of storage-reservoirs, with its mean flow at all hours. If the water could be stored during the night, all these powers could be doubled, and the power at many shoals could doubtless be considerably increased by putting up dams.

I have not considered it worth while, however, to calculate the theoretical available power between the principal shoals, as it is uncertain how much of it would be practically available. It is evident that the Dan river offers a large amount of available power and fine facilities for manufacturing.

Summary of power of the Dan River between Danville, Va., and Danbury, N. C.*

Locality.	Distance from Danville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.†				Total utilized.		Per cent. of minimum utilized.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Fall.	Horse-power, net.	
	Miles.	*Sq. ms.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*					*Feet.*		
Richmond and Danville railroad-bridge	0.000	1,989	11–12	12–13	10–11	11–12	44–48	....	....	....	....	....	....	....	....	....
Danville falls	0.500	1,989	11–12	12–13	10–11	11–12	44–48	22.00	7,500	900	1,050	4,375	1,188	8–17	180	2.28
Lynch's shoal	3.232	....	11–12	12–13	10–11	11–12	44–48	2.53	2,531	....	....	....	....	....	....	....
Long shoal	4.583	1,851	11–12	12–13	10–11	11–12	44–48	18.73	8,527	670	825	3,465	944	....	....	....
Glass' shoal	7.789	‡1,810	11–12	12–13	10–11	11–12	44–48	5.68	6,228	200	240	1,025	275	....	....	....
Butter spring shoal	9.299	....	11–12	12–13	10–11	11–12	44–48	2.78	2,420	....	....	....	....	....	....	....
Wolf island shoal	10.606	....	11–12	12–13	10–11	11–12	44–48	2.76	3,508	....	....	....	....	....	....	....
Adams' island shoal	11.986	‡1,760	11–12	12–13	10–11	11–12	44–48	4.38	4,144	150	184	770	210	....	....	....
Adams' fish-trap shoal	13.057	....	11–12	12–13	10–11	11–12	44–48	0.81	532	....	....	....	....	....	....	....
Little Island Ledge rapid	13.263	....	11–12	12–13	10–11	11–12	44–48	0.50	619	....	....	....	....	....	....	....

*Bottom rock; often at surface, always at small depth. All favorable for dams. †See pages 18 to 21. ‡Interpolated.

Summary of power of the Dan river, etc.—Continued.

Locality.	Distance from Danville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Total utilized.		Per cent. of minimum utilized.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Fall.	Horse-power, net.	
	Miles.	*Sq. ms.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*					*Feet.*		
Ware's shore	14.468	†1,735	11–12	12–13	10–11	11–12	44–48	4.35	3,794	145	180	750	205	...	...	...
Pruitt's lower shoal	15.612	...	11–12	12–13	10–11	11–12	44–48	0.37	631	...	...	...	...	...	...	...
Pruitt's upper shoal	15.768	...	11–12	12–13	10–11	11–12	44–48	0.35	657	...	...	...	...	...	...	...
Cow Ford shoal	16.394	...	11–12	12–13	10–11	11–12	44–48	0.23	689	...	...	...	...	...	...	...
Hairston's fish-trap shoal	19.094	...	11–12	12–13	10–11	11–12	44–48	0.42	559	...	...	...	...	...	...	...
Beasley's Gallows shoal	19.891	...	11–12	12–13	10–11	11–12	44–48	0.60	505	...	...	...	...	...	...	...
Tan Yard shoal	20.452	†1,675	11–12	12–13	10–11	11–12	44–48	5.28	4,399	170	211	880	241	...	...	...
Devil's Jump shoal	21.597	...	11–12	12–13	10–11	11–12	44–48	0.37	658	...	...	...	...	...	...	...
Wide Mouth shoal	23.349	...	11–12	12–13	10–11	11–12	44–48	2.17	31	...	...	...	...	...	...	...
Indian shoal	26.946	...	11–12	12–13	10–11	11–12	44–48	0.64	890	...	...	...	...	...	...	...
Sauratown ford shoal	27.54	...	11–12	12–13	10–11	11–12	44–48	0.71	901	...	...	...	...	...	...	...
Double shoal	27.835	1,639	11–12	12–13	10–11	11–12	44–48	5.85	8,619	185	228	950	260	...	...	...
Hamblin's island shoal	33.473	...	11–12	12–13	10–11	11–12	44 48	0.30	400	...	...	...	...	...	...	...
Galloway's fish-trap shoal	33.843	975	11–12	12–13	10–11	11–12	44–48	4.50	2,898	75	100	440	115	...	...	...
Galloway's island	35.536	...	11–12	12–13	10–11	11–12	44–48	0.49	1,500	...	...	...	...	...	...	...
Reese's rock shoal	37.420	†950	11–12	12–13	10–11	11–12	44–48	2.82	2,600	...	...	...	...	...	...	...
Eagle Falls	39.378	†940	11–12	12–13	10–11	11–12	44–48	3.14	1,290	...	...	...	...	...	...	...
Mulberry island shoal	43.100	...	11–12	12–13	10–11	11–12	44–48	1.38	1,250	...	...	...	...	...	...	...
Three islands shoal	45.740	...	11–12	12–13	10–11	11–12	44–48	1.62	883	...	...	...	...	...	...	...
Lone island shoal	46.240	...	11–12	12–13	10–11	11–12	44–48	1.93	1,450	...	...	...	...	...	...	...
Gravel bar	...	...	11–12	12–13	10–11	11–12	44–48	0.04	150	...	...	...	...	...	...	...
Slink shoal	48.30	...	11–12	12–13	10–11	11–12	44–48	2.58	1,074	...	...	...	...	...	...	...
Cross Rock rapid	48.60	...	11–12	12–13	10–11	11–12	44–48	0.69	150	...	...	...	...	...	...	...
Roberson's fish-trap	48.90	...	11–12	12–13	10–11	11–12	44–48	0.30	580	...	...	...	...	...	...	...
Gravel shoal	49.53	...	11–12	12–13	10–11	11–12	44–48	0.38	750	...	...	...	...	...	...	...
Gravel shoal	50.33	...	12	13	10	12	47	0.49	309	...	...	...	...	...	...	...
Beaver island shoal	51.67	...	12	13	10	12	47	2.44	1,090	...	...	...	...	...	...	...
Wolf shoal	52.57	...	12	13	10	12	47	1.20	305	...	...	...	...	...	...	...
Cross Rock shoal	53.70	...	12	13	10	12	47	2.36	1,188	...	...	...	...	...	...	...
Shoal and fish dam	54.39	...	12	13	10	12	47	1.17	381	...	...	...	...	...	...	...
Sandy island shoal	55.21	560	12	13	10	12	47	3.51	3,241	31	44	196	50	...	...	...
Carter's shoal	56.52	550	12	13	10	12	47	4.70	3,276	42	60	260	69	...	...	...
Rutley's shoal	57.56	...	12	13	10	12	47	2.09	1,288	...	...	...	...	...	...	...
Buzzard island shoal	58.40	...	12	13	10	12	47	0.52	220	...	...	...	...	...	...	...
Ladd's ford shoal	59.63	...	12	13	10	12	47	1.18	444	...	...	...	...	...	...	...
Dalton's fish-trap shoal	60.77	...	12	13	10	12	47	2.59	606	...	...	...	...	...	...	...
Granny Angel's shoal	61.44	...	12	13	10	12	47	1.33	441	...	...	...	...	...	...	...
Shoe-buckle island shoal	61.79	...	12	13	10	12	47	2.56	1,806	...	...	...	...	...	...	...
Clay's island shoal	64.21	...	12	13	10	12	47	1.40	477	...	...	...	...	...	...	...
Fish-trap shoal	65.70	†340	12	13	10	12	47	3.93	1,517	18	26	134	30	...	...	...
Hairston's Falls	66.88	328	12	13	10	12	47	14.89	2,629	66	98	492	110	...	...	...
	68.49	†320	12	13	10	12	47	6.65	3,280	30	44	213	50	...	...	...
Big Rock shoal	69.91	†315	12	13	10	12	47	8.67	4,033	38	57	270	65	...	...	...
Mount Horrible shoal	71.26	...	12	13	10	12	47	1.85	1,119	...	...	...	...	...	...	...
Williams' fish-trap shoal	71.64	...	12	13	10	12	47	1.79	390	...	...	...	...	...	...	...
Davis shoal	71.82	...	12	13	10	12	47	1.01	205	...	...	...	...	...	...	...
Cow ford shoal	72.21	†312	12	13	10	12	47	4.52	1,841	19	28	140	32	...	...	...
Ducking shoal	73.08	312	12	13	10	12	47	6.44	2,616	27	40	200	46	...	...	...
Fulcher's shoal	73.65	...	12	13	10	12	47	2.01	810	...	...	...	...	...	...	...
Sink hole shoal	74.20	...	12	13	10	12	47	1.13	1,266	...	...	...	...	...	...	...
Red shoal	74.58	†275	12	13	10	12	47	4.79	2,237	18	25	132	29	...	...	...
Old mill shoal	75.20	270	12	13	10	12	47	6.22	3,317	22	32	170	37	...	...	...
Danbury shoal	77.49	250	12	13	10	12	47	10.60	...	37	55	265	63	...	...	...
Old Iron Works shoal	...	250	12	13	10	12	47	21.00	...	75	110	525	125	...	...	...
								29.00	...	102	150	725	175	...	...	...
									Miles.							
Between Danville and mouth of Smith's river.	0 / 28	1,989 / 1,639	12	13	10	12	47	100.0	28	3,480	4,300	18,000	4,900	...	...	...
Bet. mouth of Smith's river and mouth of Mayo	28 / 49	1,039 / 900	12	13	10	12	47	56.0	21	950	1,275	5,600	1,450	...	...	...
Between mouth of Mayo and Danbury	49 / 78	580 / 250	12	13	10	12	47	150.0	29	930	1,350	6,250	1,550	...	...	...
Total between Danville and Danbury	0 / 78	1,989 / 250	12	13	10	12	47	306.0	78	5,360	6,925	29,850	7,900	...	...	...

* See pages 18 to 21. † Interpolated.

TRIBUTARIES OF THE DAN RIVER.

The first tributary of any importance above the confluence of the Dan and Staunton is Hyco river, which enters from the south, its mouth being just above the head of Little Hyco falls. This stream rises in the extreme southern part of Caswell and Person counties, North Carolina, and flows in a northeasterly direction through Halifax county, Virginia, having a total length, in a straight line, of about 45 miles, and draining an area of about 400 square miles. It is about 125 feet wide near its mouth. Its tributaries are small and unimportant, and there are no important towns on the stream. I was unable to learn much about its power. The bed and banks are said to be everywhere favorable, the former being generally rock. The only power used on the stream is for small grist- and saw-mills, none of which are extensive. No sites not used were brought to my notice, but probably numerous ones may be obtained by damming. As the stream flows parallel to the general strike of the rock strata, it is probable that the declivity is quite uniform and not broken by falls. In another table will be found the total amount of power utilized, compiled from the enumerator's reports. The rainfall on the drainage area being about 40 or 42 inches, I have estimated the flow of the stream at its mouth (see pages 18 to 21) as follows:

	Cubic feet per second.	Horse-power per foot fall.
Minimum	45	5.0
Minimum low season	64	7.3
Low season, dry years	73	8.3
Maximum, with storage	325	37.0

The next tributary of importance is the Bannister river, from the north, rising in Pittsylvania county, Virginia, and flowing a little south of east through Pittsylvania and Halifax, and joining the Dan just above King's shoal, its total length, in a straight line, being about 40 miles, its drainage area about 500 square miles, and its width near its mouth about 120 feet. It flows close by Meadsville and Halifax C. H., which are the principal towns on the stream. It has considerable fall, but is utilized only for small grist- and saw-mills, and a foundry at Meadsville. The power at this latter place is said to be fine, running, besides the foundry, a grist-mill and saw-mill; but I have not been able to obtain details regarding it. Near Riceville, Pittsylvania county, is a power with a fall of 12 feet in 900, with good sites for building on the north bank.* This power is now used by a merchant mill. I have estimated the flow and power of the stream at several points, and the results are as follows (the rainfall being in the neighborhood of 40 inches):

Place.	Drainage area.	Flow per second (see pages 18 to 21).				Horse-power per foot fall.			
		Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry year.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry year.
	Sq. miles.	*Cu. feet.*	*Cu. feet.*	*Cu. feet.*	*Cu. feet.*				
Mouth	500	60	80	400	91	6.9	9.1	45.4	10.3
Halifax	440	53	71	352	81	6.0	8.0	40.0	9.2
Meadsville	400	48	64	320	73	5.4	7.3	36.4	8.3
Riceville	246	27	37	197	42	3.1	4.2	22.4	4.8

This stream, flowing across the rock strata at large angles with their strike, like the Dan, is probably broken by rapids at various points, but no detailed information could be obtained regarding them. The elevation of the stream at the crossing of the Virginia Midland railroad near Competition, about 32 miles from its mouth, is 585 feet, and at the crossing of the Richmond and Danville railroad at Terry's bridge, some 3 miles from its mouth, it is 304 feet, giving a fall between these points of about 280 feet in a distance of, say, 30 miles, or over 9 feet to the mile—a large fall. As the distance between the two points where elevations are given above was measured from the map, and as the stream is quite crooked, the fall per mile above given is, no doubt, to some extent incorrect; but it is evident that this stream has a very large fall, and it is almost certain that very fine sites for power may be found upon it. Taking the flow at Meadsville as the average in the distance referred to, the fall of 280 feet between the Virginia Midland railroad and the mouth of the river would correspond to power as follows:

	Horse-power.
Minimum	1,512
Minimum low season	2,044
Maximum, with storage	10,192
Low season, dry years	2,324

The next tributary worth mentioning is Country-line creek, from the south, rising in Caswell county, North Carolina, and joining the Dan just on the state-line (hence the name of the stream), after flowing in a northeasterly direction for a distance of about 25 miles in a straight line and draining an area of some 130 square miles. This stream, like the others in this neighborhood, is used only for running small saw- and grist-mills. The fall is considerable, but no great falls at any one place were spoken of, and probably do not exist, as the stream flows

* Information from H. Eaton Coleman, civil and topographical engineer, county surveyor of Pittsylvania county.

nearly parallel to the strike of the rocks. The declivity is probably quite uniform, and the powers obtained only by damming. I heard of no good sites unoccupied. Near the mouth of the stream is Yarbrough's grist- and saw-mill, with a dam of wood and stone 125 feet long and 9 feet high, backing the water 1½ miles, with an average width of 100 feet. A fall of 8 feet at the mill affords a power of some 25 horse-power most of the time, but the flow of the stream is quite variable. Opposite Yanceyville the stream is considerably smaller, and will only afford about 2 or 2½ horse-power per foot fall (gross) during eight months of the year. The water-power of the stream is thus not very extensive.

The other tributaries below Danville—Moon's creek, emptying just above Wilkinson's shoal, and draining about 57 square miles, and Hogan's creek, emptying at Dix's shoal, and draining about 114 square miles—are similar in character to Hyco and Country-line creeks, and are utilized, like them, only to run small country grist- and saw-mills, the former with one or two run of stones. In a later table will be found the statement of the power used on these streams collectively, and more need not be said here.

The mills in this neighborhood are very little troubled by ice, and rarely have to stop on that account. The dams are generally of wood or of crib-work filled with stone, and there is no trouble in obtaining good foundations.

The first tributary above Danville worth mentioning is Sandy river, from the north, lying entirely within Pittsylvania county, Virginia, and emptying 1 mile above Danville. It has several grist- and saw-mills, with two or three run of stones, but no powers of importance. There is said to be a fine site for a storage-reservoir not far from the mouth.

Passing by several small creeks, the next tributary is Smith's river, from the north, a very considerable stream. Rising in the Blue Ridge, in the northern part of Patrick county, Virginia, it flows first nearly east, and, after forming for a few miles the boundary between Patrick and Franklin counties, it enters Henry county, flows through it in a southeasterly direction, and empties into the Dan, in North Carolina, just below the town of Leaksville. The distance from its source to its mouth, in a straight line, is about 36 miles, but by the river it is probably at least twice that distance. The stream flows near to Martinsville, the county seat of Henry county, it and Leaksville being the only towns of importance on the river. The total drainage area of the stream is about 600 square miles, of which 39 are in North Carolina. The drainage area above Martinsville is 330 square miles. Not having visited the river in person, on account of its inaccessibility, I am unable to describe its drainage basin very much in detail. From all that I could learn, however, it is well wooded, with a fertile soil, and abundance of fine building-stone to be had in many places, and with facilities for artificial storage, although there are no lakes. The stream has a very rapid fall, a rock bottom almost everywhere, banks of moderate height, and few low grounds subject to overflow, although it is subject to freshets, during which the water rises 20 feet in places. It is fed to a considerable extent by constant springs, and is said not to be very variable in flow; and the extensive forests are a favorable feature in this respect.

The data regarding rainfall in the basin are very incomplete, but, according to the Smithsonian charts, it may be assumed at about 44 to 48 inches, of which 12 fall in spring, 12 in summer, 10 in autumn, and 12 in winter. I have no records of continued gaugings of the stream, or of its elevations at different points.

The stream is at present not very accessible, the nearest railroad point being Reidsville, on the Richmond and Danville railroad, 14 miles from the mouth of the river. I have, however, already referred to the fact that two roads are now being built, both traversing the valley of the Dan, which will render the lower part of the stream quite accessible.

The upper parts of the river are most accessible from Rocky Mount, the county seat of Franklin county, which is connected with the Virginia Midland railroad by a branch road.

Only a small fraction of the available power on Smith's river is at present used, and with the exception of the cotton and woolen factory of J. T. Morehead & Co., near Leaksville, the only mills are country saw- and grist-mills. The Leaksville power is the only one regarding which I have detailed information, and regarding the others I must refer to the table on page 48, compiled from the reports of the enumerators.

Major Morehead's factory is located about 1 mile from the mouth of the stream, and on its west bank. The dam extends in a broken line entirely across the river, which is here about 500 or 600 feet wide, and is built partly of rubble-work in cement and partly of wood. The stone part is about 180 feet long, 13 feet high, 6½ feet thick, and was built in 1872 at a cost of $4,000, while the wooden part is built of logs, pinned to the bottom, and about 3 feet high. By extending the rock dam across the river all the water in the stream could be turned into the canal. The pond is very small, and gives no storage. A race four-fifths of a mile in length leads to the factory buildings, where a fall of 36 feet is used, and about 300 horse-power is distributed as follows among the different mills: Cotton factory, 175; woolen factory, 50; grist-mill, 50; saw-mill, 25. All these mills can run at full capacity all the time, and water is always wasting over the dam. The mills are run night and day, and are seldom troubled by high water, and only about 4 days per year by cold weather. It is said that, by extending the race, an additional fall of about 9 feet can be obtained, making 45 feet in all, in a distance of about a mile.

The river has been gauged here by H. Eaton Coleman, civil engineer, and county surveyor of Pittsylvania county, Virginia, who found the discharge to be 600 cubic feet per second "at mean low water". But as a single measurement of the flow has little value, I have made some estimates from the drainage area, and the results are given in the following table:

Table of power on Smith's river at Leaksville, N. C.

State of flow (see pages 18 to 21).	Drainage area.	Flow per second.	Horse-power available, gross.			Horse-power utilized, net.	Per cent. of minimum utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*36 feet fall.*	*45 feet fall.*		
Minimum	600	90	10.3	371	465	300	100
Minimum low season		132	15	540	675		
Low season, dry years		150	17	612	765		
Maximum, with storage		528	60	2,160	2,700		

The results in this table will be surprising to some who are prone to overestimate power. A discharge of 600 cubic feet per second at low water would correspond to 1 cubic foot per square mile of drainage area, or over 1 inch of rainfall per month, and for a dry month. An examination of the table on page 21 will show that this cannot be so unless there are some remarkable springs in the drainage-basin; and, in fact, it is sufficient to refer to the gauging of the Dan by the United States engineers, made at a point near South Boston, above which the drainage area is about 2,600 square miles, and which gave 990 cubic feet per second "at low water", but probably not the minimum. Even this would give per 600 square miles of drainage area, if the discharge is taken proportional to the drainage area, only 229 cubic feet per second, and the absolute minimum would be considerably less. The flow in the dry season of ordinary years would, perhaps, be 190 cubic feet per second, giving about 775 horse-power, with a fall of 36 feet. My estimate gives 100 per cent. of the minimum power used, but Major Morehead states that they "can't miss the water used by the mills". It is not impossible that the power utilized has been overestimated, which would tend to explain this result. The cotton factory runs 101 looms and about 4,800 spindles. The goods manufactured are brown sheetings, yarns, sewing-thread, and knitting-cotton. In the woolen-mill there is one set of cards, and in the grist-mill 4 run of stones. According to these data, without further particulars, 300 horse-power would seem to be too high an estimate of the power utilized. It is evident, however, that this power is a most excellent one in all respects—one of the finest in northwestern North Carolina. Reidsville is Major Morehead's shipping point.

About 2,000 feet above Major Morehead's dam is a fall of about 6 feet in 50, not used, but easily controlled.* It might be used at the factory below by raising the dam.

The power above this point is used only by saw- and grist-mills, in regard to which I have no detailed information. Enough was learned, however, to show that the river offers fine sites for power all the way up, the principal disadvantage being their inaccessibility. The river has no tributaries of much importance.

The town of Leaksville has a considerable trade in tobacco, which is the great staple of the county; but wheat and corn are also grown in considerable quantities on the fertile bottoms of the Dan, Smith, and Mayo rivers.

Above Smith's river are several unimportant tributaries to the Dan, on some of which are small mills. They are similar in character to the other tributaries below Smith's river. On Cascade creek, a small stream entering from the north below Smith's river, Dr. J. G. Brodneax has a small saw- and grist-mill, and a very good small power, with a fall of 15 or 16 feet. Timber is very cheap in this vicinity, and wooden dams can be erected at very small cost.

The next large tributary above Smith's river is Mayo river, from the north, a stream which, like Smith's river, takes its rise on the eastern slope of the Blue Ridge, in the western part of Patrick county, Virginia, and which, after flowing in a general southeasterly direction through Patrick county and a corner of Henry county, Virginia, and Rockingham county, North Carolina, joins the Dan a little below Madison, and just above Roberson's fish-trap shoal. Its length, in a straight line, is about 55 miles, and along the general course of the stream about 60 miles, but probably considerably more if all of its windings are followed. The only town on the stream is Taylorsville, the county seat of Patrick county. Its total drainage area is about 316 square miles, of which 60 square miles are above Taylorsville, and its principal tributary is the North Mayo, from the north, draining about 90 square miles. Its drainage-basin is, in all respects, similar to that of Smith's river. The fall of the stream is considerable, but it is said to be more uniform than that of either the Dan or Smith's river, and with not so many rapids and falls. The bed is rock almost everywhere, the banks high, and not many low grounds subject to overflow. In the absence of gaugings I have estimated the flow and the power of the stream at its mouth as in the following table:

Flow and power of Mayo river at its mouth.

State of flow (see pages 18 to 21).	Drainage area.	Flow per second.	Horse-power available, gross.
	Square miles.	*Cubic feet.*	*1 foot fall.*
Minimum	316	40	4.7
Minimum low season		57	6.5
Low season, dry years		65	7.4
Maximum, with storage		278	31.6

* Information from Major Morehead.

The power on the stream is used only for small grist- and saw-mills, but there are many sites not in use. The first, ascending the river, is about 1 mile from Madison, and the same distance from the mouth of the stream, used until recently for a corn- and saw-mill. The dam is a natural ledge, and the total fall of the shoal is said to be 32 feet. This site has not been used for ten years, but is said to be one of the best in the vicinity, with safe location for mills and little trouble with high water or overflow. It is owned by Mr. Robert Lewis.

About 2 miles further up the stream is a flour-mill, and above there are other small ones. There is very little bottom-land on the river for some six miles from its mouth, and the fall in that distance is very considerable, ledges of rock crossing the stream all the way. Above this, however, the stream is flat for 15 or 20 miles, and the facilities for power are not so good.

Above the Mayo there are several small creeks flowing into the Dan, some of which have power used, and all of which have considerable available. They are good streams for power, and, so far as I can learn, are not subject to such great variations in flow as those farther east. The powers they afford are small, but sufficient to run small grist- and saw-mills—sufficient for the needs of the people. Being easily dammed, and having considerable fall, they are preferred to the Dan river for small powers. The most important tributary above the Mayo is Town fork, which joins the Dan just above Shoe-Buckle island shoal; but regarding it or the other tributaries above I have no detailed information.

All of these tributary creeks, as well as the Dan river itself, are subject to sudden and quite heavy freshets, but they have so much fall that, in general, not much damage is done, although on the Dan, even above Danville, there are many bottoms which are overflowed at times. The freshets are, in general, short, lasting usually, it is said, only four or five days.

Finally, it may be said of all the valley of the Dan, and particularly of the upper part, that the climate is exceedingly salubrious (much more so than in the valley of the Roanoke, especially its lower part), the soil fertile, and the people industrious and hospitable. The advantages for manufacturing are, in every respect, excellent, except as regards accessibility, and it is to be hoped that the two railroads which are now projected up the valley may soon remove that objection.

THE STAUNTON RIVER.

This stream rises in Montgomery and Floyd counties, Virginia; flows first northeast into Roanoke; thence southeast, forming the boundary between Bedford, Campbell, and Charlotte on its left, and Franklin, Pittsylvania, and Halifax on its right, uniting with the Dan in Mecklenburg to form the Roanoke. Its length, in a straight line, is about 110 miles, and by the general course of the river perhaps 200, and still more if all its windings are followed. There are no large towns on the stream. The river is known as the Roanoke in the upper part of its course, in Montgomery and Roanoke counties.

The river and harbor bill of June 18, 1878, authorized a survey of the river between Brook Neal and Roanoke station, on the Richmond and Danville railroad, which was executed by Mr. S. T. Abert, whose reports are to be found in the reports of the Chief of Engineers, 1879, p. 622, and 1880, p. 780. By the act of March 3, 1879, the sum of $5,000 was appropriated for the work of improving the navigation of the river between these points, and by that of June 14, 1880, $7,500. The present project contemplates the securing of a navigable channel not less than 35 feet wide and 2 feet deep through the ledges and sand-bars, and a slope of water-surface at the rapids not greater than 10 feet to the mile, the cost being estimated at $57,670. These are the only works of navigation projected on the river. The stream is now navigable to Cole's ferry, a distance of 45½ miles, the depth being 1½ feet at low water.

The Staunton river drains a total area of about 3,450 square miles. Proceeding up the river, its principal tributaries from the north are, in their order, Bluestone creek, Ward's fork, Falling river, Otter river, Goose creek, and from the south, in the same order, Pig and Blackwater rivers.

The drainage-basin of the Staunton resembles that of the Dan so closely that a detailed description will not be necessary. The map annexed will show its general form and dimensions. As regards the bed and banks of the stream, the freshets, the facilities for storage, the soils, vegetation, people, and products, all the general remarks which were made in the case of the Dan will apply also to the Staunton. The river takes its source, however, considerably higher in the mountains than the Dan, its source being west of the Blue Ridge, through a gap in which it passes at the northern edge of Franklin county. One of the effects of this will be, perhaps, to render the flow of the stream more variable than that of the Dan, and from what I can learn its freshets seem to be rather more violent, the river rising between 30 and 40 feet above low water between Brook Neal and Roanoke station. But another effect of the position of the sources of the river beyond the Blue Ridge will be that the amount and distribution of the rainfall on its upper part will be different from what they are in the basin of the Dan; and although I am unable to state with accuracy to what extent or just in what way, it seems probable, from the Smithsonian charts, that the amount of rainfall will be rather less in the case of the Staunton, while its distribution through the year will be a little more uniform—less rain falling in winter on the upper Staunton than on the upper Dan. It does not seem improbable that the resultant effect of these changes will be to render the flow of the Staunton, as a whole, smaller in proportion to its drainage area than that of the Dan, while the freshets of the

former may, perhaps, be more violent. As a whole, however, the mean annual rainfall on the basin of the Staunton may be taken at 42–44 inches, of which 12 fall in spring, 10 or 12 in summer, 10 in autumn, and 10 in winter.

The following table will show the declivity of the river:

Staunton river—Table of declivity.

Place.	Distance from Clarksville.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Clarksville, mouth of river	0	269	22	36	1.64
Roanoke station, crossing of Richmond and Danville railroad	22	305	32	50	1.56
Brook Neal, end of United States survey	54	355	30	145	4.83
Crossing of Virginia Midland railroad	84	500	90	570	6.33
Crossing of Atlantic, Mississippi and Ohio railroad, 6 miles west of Salem	174	1,070	12	175	14.58
Crossing of Atlantic, Mississippi and Ohio railroad, 1 mile west of Big Spring	186	1,245			

The elevations given were furnished by railroad officials, with the exception of those of Clarksville and Brook Neal, which are calculated from government reports. The distances were measured on the map, following the windings of the rivers as nearly as possible, and they are believed to be very nearly accurate.

In the twenty-second report of the board of public works of Virginia is a report on a survey of the Staunton river by J. J. Couty. It is there stated that the fall from the Dan river, at the head of Nelson's island—probably at Skipwith's thoroughfare—to Brook Neal is 84.85 feet in a distance of nearly 49 miles, which agrees quite well with the figures given above.

Mr. Abert states that, according to an old survey, the fall from Smith's gap, where the river breaks through the Blue Ridge, to Clarksville—a distance of 112 miles—is 322.61 feet, or, on the average, 2.88 feet per mile.

No records of gaugings being at hand, I am again obliged to resort to estimates of flow and power based on the drainage areas.

The river is crossed by four railroads: by the Richmond and Danville road at Roanoke station, about 22 miles above Clarksville (by the river); by the Virginia Midland road at a point between Ward's bridge and Leesville, about 84 miles above Clarksville; and by the Atlantic, Mississippi and Ohio road at a point a little west of Salem, and about 174 miles above Clarksville; and further on again, at a point some 186 miles above the same place; but as the two first-named roads cross the stream nearly at right angles, all that portion of the river lying east of the Blue Ridge is very inaccessible, as will be seen from the map, except that portion for a short distance above the crossing of the Virginia Midland road, which is accessible from the branch of that road extending to Rocky Mount, Franklin county. That portion which lies west of the Blue Ridge is easy of access from stations on the Atlantic, Mississippi and Ohio railroad, which follows the valley of the stream for some distance.

I found it difficult to obtain much information regarding the water-power of the stream. The country is thinly settled, and the people have paid very little attention to the subject of water-power, there being only small grist- and saw-mills, with a foundry or two, in the whole valley of the Staunton. The power at present utilized is tabulated below from the returns of the enumerators, but regarding the available power I cannot present any definite figures. There is no doubt, however, that the Staunton and its tributaries offer many valuable sites for power, some of which could be rendered available at a very small cost. The following brief notes comprise all the information that I was able to collect with the limited time at my disposal.

Below Roanoke station, although there are some rapids, very little power ever has been used, and only for primitive grist- and saw-mills, the former running two or three sets of stones. The principal fall occurs at Tally's falls, but regarding it I have no particulars. The average width of the river in this section of its course is about 450 feet, but at Tally's falls it is wider, and the channel is broken up with rocks and islands.

Between Roanoke station and Brook Neal the river is navigated by bateaux, and by a small steamer drawing 14 inches when loaded, which is, however, unable to navigate the stream at low stages of the water. The land in this vicinity is very fertile, and is believed to be the best tobacco land in the state of Virginia. The width of the river in this section varies from 260 to 300 feet, and the banks are 12 to 22 feet high. In November, 1877, a flood occurred, which was the highest known in this vicinity, the rise being 36.33 feet above low-water at Roanoke station and 43 feet at one other point (Cole's ferry); but the banks being protected by a continuous fringe of willows, whose fibrous roots hold the soil together very effectively, are not much affected by the current, even in such heavy freshets.

The principal shoals between Roanoke station and Brook Neal are given in the following table, taken from Mr. Abert's report. Whether these shoals are practically available for power I cannot say, but it is evident that none of the shoals present remarkable powers, like some of those on the Dan.

Above Brook Neal there are several shoals with considerable fall, mention having been made of Seven Islands shoal, just above Brook Neal, Rowark's falls, and Dudley's falls. There are also several small grist-mills on the stream, all having rough wing-dams. There is said to be not a single dam entirely across the stream, except perhaps up in the mountains.

The estimates of power given in the latter part of the table are entitled to little reliance, and are only inserted to give a rough idea of the available power of the river as compared with that of the Dan. If these estimates are much out of the way, they are wrong for both rivers probably, because similar suppositions have been made in both cases.

Staunton river—Summary of power.

Locality.	Distance from Clarksville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*			
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.
	Miles.	*Sq. ms.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*				
Clark's shoal	25.93	....	12	10–12	10	10	42–44	0.891	1,640	....	....	....	....
Watkins' reef	27.39	....	12	10–12	10	10	42–44	0.694	650	....	....	....	....
Horseback shoal	28.26	....	12	10–12	10	10	42–44	6.426	18,890	....	....	....	....
Hawk Mountain shoal	32.77	....	12	10–12	10	10	42–44	3.774	3,450	....	....	....	....
Cove shoal No. 3	34.00	....	12	10–12	10	10	42–44	0.707	2,190	....	....	....	....
Cove shoal No. 2	34.70	....	12	10–12	10	10	42–44	0.247	1,920	....	....	....	....
Cove shoal No. 1	35.67	....	12	10–12	10	10	42–44	0.981	2,420	....	....	....	....
Britton's shoal	38.84	....	12	10–12	10	10	42–44	1.411	1,780	....	....	....	....
Dennis' dam	41.25	....	12	10–12	10	10	42–44	0.979	890	....	....	....	....
Rice's shoal	41.93	....	12	10–12	10	10	42–44	1.391	1,370	....	....	....	....
Michael's dam	43.43	....	12	10–12	10	10	42–44	0.500	185	....	....	....	....
Bruce's shoal	43.86	....	12	10–12	10	10	42–44	2.945	10,970	....	....	....	....
Kirkpatrick's shoal	45.86	....	12	10–12	10	10	42–44	2.733	7,510	....	....	....	....
Henry's shoal	49.79	....	12	10–12	10	10	42–44	2.403	4,425	....	....	....	....
Miller's shoal	51.23	....	12	10–12	10	10	42–44	0.996	785	....	....	....	....
White Rock falls	51.91	....	12	10–12	10	10	42–44	3.090	1,075	....	....	....	....
Between mouth and mouth of Falling river	0 54	3,450 2,722	12	10–12	10	10	42–44	86.00	*Miles.* 54	5,400	6,600	24,000	7,500
Between mouth of Falling river and mouth of Otter river	54 80	2,509 2,257	12	10–12	10	10	42–44	125.0±	26	6,100	7,500	28,500	8,600
Between mouth of Otter river and mouth of Goose river	80 91	1,892 1,836	12	10–12	10	10	42–44	60.0±	11	2,275	2,775	10,500	3,175
Between mouth of Goose river and mouth of Pig river	91 102	1,556 1,500	12	10–12	10	10	42–44	70.0±	11	2,000	2,600	10,500	2,975
Between mouth of Pig river and mouth of Blackwater river	102 113	1,088 1,043	12	10–12	10	10	42–44	70.0±	11	1,250	1,675	7,350	1,900
Between mouth of Blackwater river and railroad crossing near Salem	113 174	730 250±	12	10–12	10	10	42–44	386.0±	61	3,000	4,200	19,000	4,800
Total between mouth and Salem	0 174	3,450 250±	12	10–12	10	10	42–44	800.0±	174	20,025	25,350	99,850	28,950

* See pages 18 to 21.

TRIBUTARIES OF THE STAUNTON RIVER.

The first tributary met with in ascending the river is Bluestone creek, entering from the north in Mecklenburg county, about 3 miles above Clarksville, its sources being in Charlotte county, and its general course nearly south. Its length is about 17 miles, and its drainage area about 85 square miles. Details regarding its water-power could not be obtained.

The next stream worth mentioning is Ward's fork, also from the north, and draining an area of 191 square miles, entirely in Charlotte county. Its course is nearly south, and its length, in a straight line, about 20 miles. This stream is sometimes known as the Little Roanoke. Regarding its available power I have no data. That which is used is tabulated beyond. The elevation of the stream at the crossing of the Richmond and Danville railroad, some 4 miles from its mouth, is 322 feet.

Falling river, the next tributary worth naming, enters the river about 2 miles below Brook Neal, from the north. Its length is about 25 miles along its general course, and it drains an area of about 213 square miles in Campbell and Appomattox counties. It has considerable fall, and is said to be a good stream for power, running several saw- and grist-mills and a foundry, all herein tabulated. Details of its available power could not be obtained with the time at disposal. In fact, examinations of all these streams would be necessary if any accurate conception of their value for power is to be formed. The information given by most persons with whom I orresponded in this section of the country was very general, being mostly confined to statements that the streams had "a rapid fall", "plenty of sites for manufacturing establishments", and the like.

Otter river is the next considerable tributary, being larger than any thus far mentioned. It rises near the Peaks of Otter, in the Blue Ridge, in the northwestern part of Bedford county, whence it pursues a general course nearly southeast through Bedford and Campbell counties, entering the Staunton in the latter county, about 4 miles

below the crossing of the Virginia Midland railroad. Although there are very few mills on the stream, as will be seen by turning to the table, it is said to be an excellent stream for power, and it must certainly have a very large fall, descending, as it does, from the Blue Ridge. Its length is about 35 miles, following its general course, and it drains an area of 365 square miles. Its water-power must be very considerable, and I think there is no doubt that fine sites may be found along it at many points, although I heard of no particular ones.

The next tributary, the Goose river, enters the Staunton from the north at Leesville, about 7 miles, by the stream, above the crossing of the Virginia Midland railroad. It rises, like the Otter river, on the eastern slope of the Blue Ridge, and flows during its whole course nearly parallel to the latter stream, which it much resembles in general character. Its length is about the same, but its drainage area smaller, viz, 280 square miles. Like the Otter, its water-power is utilized only for a few small grist- and saw-mills, although its available power must be considerable.

Pig river, from the south, is the next important tributary, being in fact the largest tributary of the Staunton. It rises in the Blue Ridge near the southwestern corner of Franklin, pursues a course nearly east through that county and into Pittsylvania, where it makes a bend to the north and enters the Staunton about 11 miles, by the river, above Leesville, its total length, following its general course, being about 45 or 50 miles, and its drainage area about 413 square miles. It receives as tributaries several large creeks, all of which are said to afford good power. The Pig river is a rapid stream, and probably affords many sites for power—in fact, there seems no doubt that it does—but it is scarcely used at all, as the table of statistics shows.

The last tributary of the Staunton worth mentioning specially is Blackwater river, which rises in the western part of Franklin county, pursues a course nearly parallel to that of Pig river, and joins the Staunton about a mile above the northeast corner of Franklin county. Its total length, following its general course, is about 35 miles, and its drainage area 313 square miles. It is fair to conclude that its general character is nearly the same as that of Pig river, and that it affords a very large amount of unutilized power.

The information which I am able to present regarding these tributaries of the Staunton, notwithstanding the large amounts of power they possess, is very meager, and this is due to several causes, among which may be mentioned their inaccessibility in general, and the fact that so little power is used on them that it is difficult to find persons well acquainted with their water-power. It is also due in great measure to the fact that, unlike the streams farther south, their declivities are, on the whole, quite uniform, with few precipitous falls. As regards their general character, their banks are said to be good as a rule, and their beds are gravel and sand, with rock never at a great depth, and sometimes at the surface. Most of the low grounds along their banks are subject to overflow in times of freshet, the latter being severe, but short. This region is, in fact, a sort of a transition district from the glacial region of the north, where the streams flow in beds of gravel and sand, cut down into the deposits of glacial drift, and with uniform declivities, and the non-glacial southern region, where drift-deposits do not occur, except in the eastern division, and where the streams pour often over ledges of rock which cross their course, falling often 20 to 50 feet in a few hundred, and without having evened out their beds to a uniform declivity and obliterated these falls by filling them up with deposits brought down from above.

While the streams of the middle states have comparatively few precipitous falls, those of the southern Atlantic states have many. But although there are no drift-deposits in the middle and western divisions of these states, there are quite extensive deposits of gravel and sand which owe their origin to other causes; and there will be occasion to show that many of the southern streams are gradually filling up and evening out their beds to a uniform declivity, as the streams of the middle states have already done.

The following table contains some estimates of the flow of the Staunton and its tributaries, not entitled to much confidence, but serving to give a rough idea of the power they would afford (see pages 18 to 21):

Staunton river and tributaries—Table of estimated flow and power.

River and place.	Drainage-basin.	Rainfall.					Flow, per second.				Horse-power available, 1 foot fall, gross.			
		Spring.	Summer.	Autumn.	Winter.	Year.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*				
Staunton, at mouth	3,450	12	10–12	10	10	42–44	655	759	2,760	867	74.5	86.2	313.6	98.5
Staunton, above Bluestone	3,365	12	10–12	10	10	42–44	605	740	2,690	845	68.8	84.1	306.0	96.0
Staunton, above Ward's fork	3,033	12	10–12	10	10	42–44	546	667	2,425	762	62.0	75.8	275.0	86.6
Staunton, above Falling river	2,509	12	10–12	10	10	42–44	450	550	2,000	630	51.1	62.5	227.0	71.6
Staunton, above Otter river	1,892	12	10–12	10	10	42–44	321	397	1,600	450	36.5	45.1	182.0	51.1
Staunton, above Goose river	1,556	12	10–12	10	10	42–44	256	326	1,322	373	29.2	37.1	150.0	42.4
Staunton, above Pig river	1,088	12	10–12	10	10	42–44	163	218	957	250	18.5	24.8	109.0	28.4
Staunton, above Blackwater river	730	12	10–12	10	10	42–44	109	146	642	167	12.4	16.6	73.0	19.0
Bluestone creek	191	12	10–12	10	10	42–44	....	....	....	....	....	....	....	....

Table of estimated flow and power—Continued.

River and place.	Drainage basin.	Rainfall. Spring.	Summer.	Autumn.	Winter.	Year.	Flow, per second. Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power available, 1 foot fall, gross. Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*				
Ward's fork (Little Roanoke)	85	12	10–12	10	10	42–44								
Falling river	213	12	10–12	10	10	42–44								
Otter river	365	12	10–12	10	10	42–44	51	73	321	83	5.8	8.3	36.5	9.4
Goose river	280	12	10–12	10	10	42–44	39	56	246	64	4.5	6.3	28.0	7.2
Pig river	413	12	10–12	10	10	42–44	58	82	363	94	6.6	9.3	41.3	10.7
Blackwater river	313	12	10–12	10	10	42–44	44	62	275	71	5.0	7.1	31.3	8.1

Roanoke river and tributaries—Table of power utilized.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
Roanoke river	Albemarle sound	North Carolina	Bertie	Saw	1		30
	Do	do	Northampton	Flour and grist	2	16	76
	Do	do	Halifax	do	3	54	110
	Do	do	do	Saw	1	18	10
	Do	do	do	Cotton-gin	2	36	15
	Do	do	do	Foundry	1	18	15
	Do	Virginia	Mecklenburg	Flour and grist	2	11½	41
	Do	do	do	Saw	2	11½	41
Tributaries of	Roanoke river	North Carolina	Washington	Flour and grist	2	18	22
	Do	do	Bertie	do	4	34½	67
	Do	do	do	Saw	2	16	35
	Do	do	Martin	do	2	19	42
	Do	do	do	Flour and grist	3	29	40
	Do	do	Northampton	do	3	29	32
	Do	do	Warren	do	7	111	178
	Do	do	do	Saw	4	54	82
	Do	do	Granville	Flour and grist	13	178½	163
	Do	do	do	Tobacco	1	10	8
	Do	do	do	Saw	4	59½	62
	Do	Virginia	Mecklenburg	do	8	110	171
	Do	do	do	Flour and grist	17	260	331
	Do	do	do	Cotton-gin	1	31	16
Dan river	Do	do	Halifax	Flour and grist	3	21	60
	Do	do	Pittsylvania	do	2	25	65
	Do	do	do	Saw and planing	1	7	50
	Do	do	do	Foundry and machine-shop.	2	17	70
	Do	North Carolina	Stokes	Flour and grist	2	25	38
Hyco river	Dan river	do	Person	do	2	26	34
	Do	do	do	Saw	2	26	26
	Do	do	Caswell	Flour and grist	3	41	44
	Do	Virginia	Halifax	do	2	18	35
	Do	do	do	Saw	1	8	20
Bannister river	Do	do	Pittsylvania	Flour and grist	2	24	40
	Do	do	Halifax	do	3	35	148
	Do	do	do	Saw	1	10	20
	Do	do	do	Tobacco	1	10	18
Smith's river	Do	North Carolina	Rockingham	Cotton factory	1	36	175?
	Do	do	do	Woolen factory	1	36	50?
	Do	do	do	Flour and grist	1	28	50
	Do	do	do	Saw	1	12	20
	Do	do	do	Millwrighting	1	28	35
	Do	Virginia	Henry	Flour and grist	2	20	60
	Do	do	do	Saw	3	46	83
	Do	do	Patrick	Flour and grist	1	13	20
Mayo river	Do	North Carolina	Rockingham	do	1	20	20
	Do	Virginia	Patrick	do	1	15	16
Other tributaries of	Do	North Carolina	Granville	do	3	46	40
	Do	do	do	Saw	2	53	30

Table of power utilized—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
Other tributaries of	Dan river	North Carolina	Person	Saw	4	......	65
	Do	do	do	Flour and grist	6	89	92
	Do	do	Caswell	do	14	176	216
	Do	do	do	Saw	8	82	126
	Do	do	do	Agricultural implements.	2	32	30
	Do	do	Rockingham	Flour and grist	12	169½	203
	Do	do	do	Saw	9	120+	145
	Do	do	do	Blacksmithing	1	10	6
	Do	do	Stokes	Flour and grist	18	264	285
	Do	do	do	Saw	7	96½	130
	Do	Virginia	Halifax	Flour and grist	19	344	354
	Do	do	do	Saw	11	243	194
	Do	do	do	Foundry	1	8	8
	Do	do	do	Agricultural implements.	3	37	24
	Do	do	Pittsylvania	Flour and grist	18	307	412
	Do	do	do	Saw	4	77	70
	Do	do	Henry	Flour and grist	19	331	241
	Do	do	do	Saw	6	142	121
	Do	do	do	Agricultural implements.	1	17	30
	Do	do	do	Leather	1	16	6
	Do	do	Patrick	Flour and grist	1	15	15
Staunton	Roanoke	do	Halifax	do	1	6	12
	Do	do	do	Saw	1	14	15
	Do	do	Charlotte	Flour and grist	1	10	25
	Do	do	Campbell	do	3	14½	135
	Do	do	Bedford	do	2	18	20
	Do	do	do	Saw	1	3	7
	Do	do	Pittsylvania	do	1	14	12
	Do	do	Roanoke	do	1	10	16
	Do	do	do	Flour and grist	3	30	60
	Do	do	Montgomery	do	2	25	45
	Do	do	do	Saw	1	......	20
	Do	do	do	Furniture	1	10	6
Little Roanoke	Staunton	do	Charlotte	Flour and grist	2	10	32
	Do	do	do	Saw	1	7	18
Falling creek	Do	do	Campbell	Foundry	1	10	20
	Do	do	do	Flour and grist	3	35	79
	Do	do	Appomattox	do	1	12	27
	Do	do	do	Saw	1	12	25
Otter river	Do	do	Bedford	Flour and grist	3	44	43
	Do	do	do	Saw	3	45	35
	Do	do	do	Woolen	1	......	......
	Do	do	Campbell	Flour and grist	1	2	25
Goose river	Do	do	Bedford	do	6	77	93
	Do	do	do	Saw	4	58	32
Pig river	Do	do	Franklin	Flour and grist	4	......	62
	Do	do	do	Saw	1	16	25
Blackwater river	Do	do	do	Flour and grist	2	28	22
	Do	do	do	Saw	1	9	20
Other tributaries of	Do	do	Halifax	Flour and grist	6	86	111
	Do	do	Charlotte	do	10	199	223
	Do	do	do	Saw	2	41	36
	Do	do	Campbell	Flour and grist	8	105½	238
	Do	do	do	Saw	2	26½	60
	Do	do	Bedford	Flour and grist	15	229	253
	Do	do	do	Saw	10	151	136
	Do	do	Pittsylvania	Flour and grist	1	18	12
	Do	do	do	Saw	2	26	36
	Do	do	Franklin	do	5	80	50
	Do	do	do	Flour and grist	21	310	307
	Do	do	do	Wheelwrighting	1	15	4
	Do	do	Roanoke	Flour and grist	12	176	252
	Do	do	do	Saw	8	100	105
	Do	do	do	Foundry	1	7	4
	Do	do	do	Fertilizers	1	22	15
	Do	do	Montgomery	Flour and grist	2	21	28

III.—THE TAR RIVER AND TRIBUTARIES.

THE TAR RIVER.

This river takes its rise in Person and Granville counties, North Carolina, flows in a southeasterly direction through Franklin, Nash, Edgecombe, and Pitt counties, and empties into the Pamlico river, in Beaufort, near the town of Washington, its length, in a straight line, being about 120 miles, and by the river perhaps 175. The principal towns on the stream are Washington, Greenville, Tarboro', Rocky Mount, and Louisburg. Tarboro', 53 miles from Pamlico river, is the head of navigation, and it is hoped to secure ultimately a channel 3 feet in depth at all stages of the water up to this point, but at present this depth exists only during nine months of the year. The obstructions to navigation consist of stumps, snags, fallen trees, and artificial obstructions placed there during the war.

The river drains an area of about 3,000 square miles, the greater part of which lies north of the stream, from which side the principal tributaries—Swift and Fishing creeks—enter, draining, respectively, 340 and 760 square miles. The stream crosses the fall-line at Rocky Mount, below which point there is no water-power. The general character of the drainage-basin resembles that of the Roanoke. The leading productions are tobacco, corn, and cotton, most of the cotton being raised in the eastern part, and most of the tobacco in the western. There are no lakes in the basin. The bed of the stream above the fall-line is rock in places, but generally sand, clay, gravel, or mud, the declivity of the stream being quite uniform. Above Rocky Mount the bottoms are narrower than on the Roanoke, and the banks are generally high enough to confine the river, except in very heavy freshets. Below Rocky Mount the banks are often overflowed, the river rising sometimes 25 feet at Tarboro'.

The average annual rainfall on the basin of the Tar is about 50 inches, but above the fall-line it is less—about 46 or 48 inches, distributed nearly as follows: Spring, 12; summer, 14; autumn, 10; winter, 11.

The fall of the stream below Rocky Mount is said not to exceed 1 or 1½ feet per mile, making the total fall below that point between 50 and 75 feet. The elevation of the stream at the crossing of the Raleigh and Gaston railroad is 188 feet,* making the fall between that point and the head of the fall at Rocky Mount about 2 feet to the mile or less, the distance being in the neighborhood of 60 miles. No gaugings of the stream are on record.

Ascending the stream the water-powers met with are as follows:

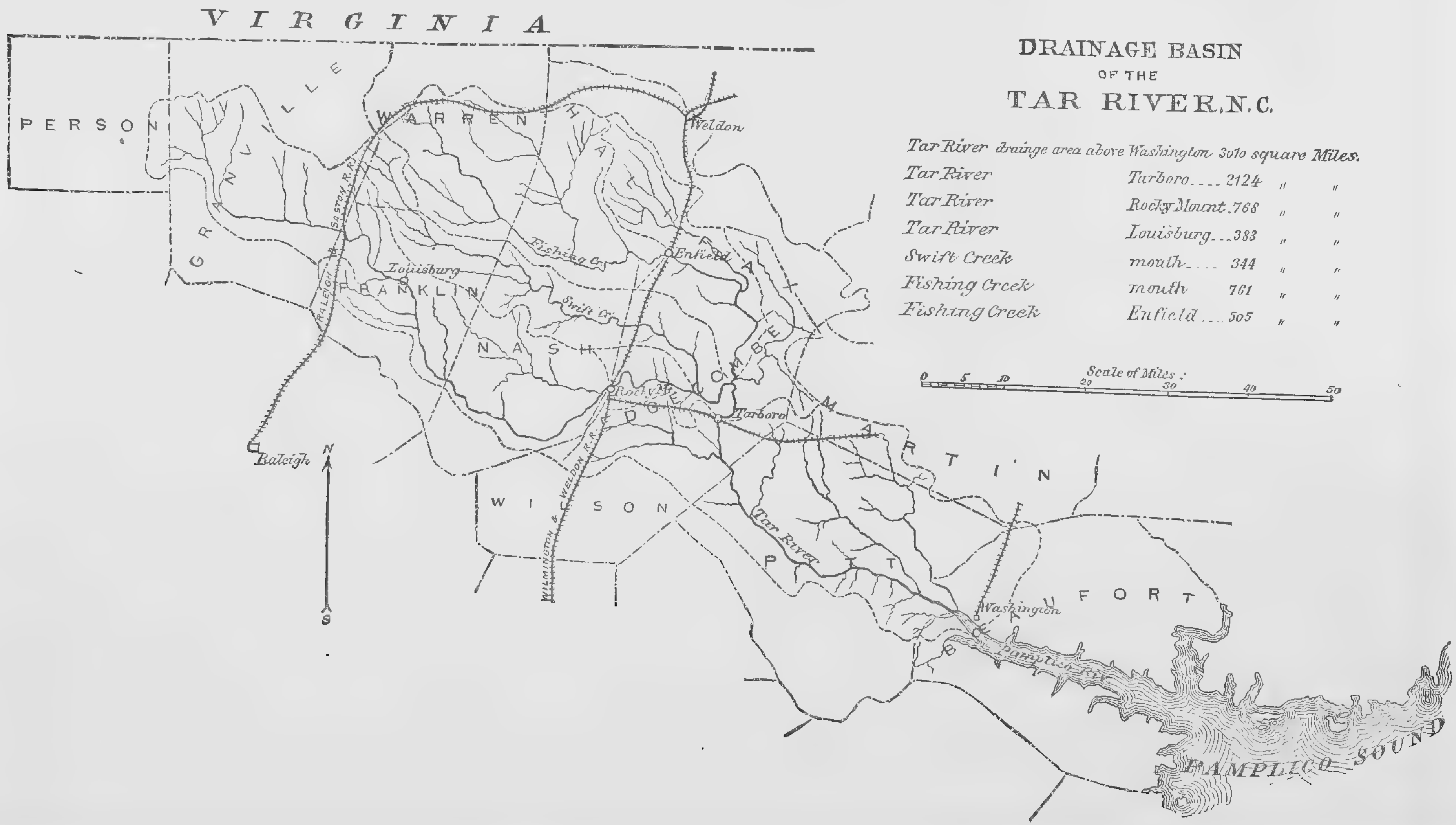
Battle's cotton factory, at Rocky Mount, known as the Rocky Mount mill, is situated on the fall-line. The dam extends entirely across the river in a broken line, part being artificial, and part natural rock. The artificial part is of granite, 600 feet long, and averaging 9.2 feet in height, and was built in 1854 at a cost of $10,000. It backs the water up only a very few hundred feet, forming no pond of any consequence. The bed of the stream is solid rock and the banks moderately high, affording safe building-sites. There is considerable fall in the stream for several hundred yards above the dam, which could probably be raised some four feet or so without doing any damage, and backing the water up to the head of a slight rift called Goodson's falls (half a mile above the dam), above which the river is sluggish for a long distance. A race 191 feet long leads from the dam to the cotton factory, where a head and fall of 16 feet 10 inches is used, with a turbine-wheel giving 155 horse-power. No steam-power is used, the water-power being ample, and there being an excess of water at all times, except in very low stages of the river. In addition to the cotton factory there is a grist- and flour-mill located at the dam, run by two overshot wheels, with 14½ feet fall and about 40 horse-power; also a saw-mill run by a turbine-wheel, with 12 feet fall and about 30 horse-power, and a second turbine-wheel, running a cotton-gin, with about 10 horse-power. The total power used at this place is therefore about 235 horse-power. It is said that the first cotton-mill in the state of North Carolina was built at this place in 1817.

The drainage area above this place is about 768 square miles, and the mean annual rainfall about 47 inches, already stated. No gaugings of the river having been made, I have been obliged to estimate the flow and the power with the results given in the following table. The total available fall may be taken as 20 feet:

Power on the Tar river at Rocky Mount.

Character of flow, (see pages 18 to 21.)	Drainage area.	Fall.	Flow per second.	Available horse-power, gross.			Utilized.		Per cent. of minimum utilized.
							Horse-power, net.	Fall.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*16⅚ foot fall.*	*20 foot fall.*		*Feet.*	
Minimum	768	20	125	14.0	235	280	235	12–16⅚	133
Minimum low season			150	17.0	286	340			
Maximum, with storage			675	76.8	1,293	1,536			
Low season, dry years			170	19.2	323	384			

* For the elevations on the Raleigh and Gaston railroad and the Raleigh and Augusta Air-Line railroad I am indebted to the general manager, Mr. John C. Winder.



DRAINAGE BASIN
OF THE
TAR RIVER, N.C.
Tar River drainge area above Washington 3010 square Miles.
Tar River Tarboro....2124 " "
Tar River Rocky Mount.768 " "
Tar River Louisburg...383 " "
Swift Creek mouth.... 344 " "
Fishing Creek mouth 761 " "
Fishing Creek Enfield....505 " "
Scale of Miles:
0 5 10 20 30 40 50
VIRGINIA
PERSON
GRANVILLE
WARREN
HALIFAX
FRANKLIN
NASH
EDGECOMBE
WILSON
MARTIN
PITT
BEAUFORT
RALEIGH & GASTON R.R.
WILMINGTON & WELDON R.R.
Weldon
Enfield
Louisburg
Fishing Cr.
Swift Cr.
Rocky Mt.
Tarboro
Raleigh
N
S
Tar River
Washington
Pamplico Riv.
PAMPLICO SOUND

In very low stages of the river the water is drawn down in the pond below the crest of the dam sometimes to the extent of 6 inches; but as the pond is very small, this does not indicate that the power used is much in excess of that due to the natural flow, but only that the latter is completely utilized. Neither is Mr. Battle troubled, to any great extent, by freshets, being only obliged to stop at most a few days in the year. The dam was partially carried away in 1875, but no great damage was done. There is never any trouble with ice.

The estimates given in the above table for the power available, with storage, although it might be approximated to in the case of the Tar, whose drainage-basin is, in the upper parts, favorable in places for the construction of reservoirs, according to Professor Kerr, yet the use of this method of increasing the power would probably, as in the case of the Roanoke, be found expensive and impracticable, on account of the necessity of overflowing lands which are the most fertile and the best adapted to cultivation in the whole basin, and on account of the distance of the reservoir-sites from the fall-line. As the factory is almost on the line of the Wilmington and Weldon railroad, the facilities for transport are excellent. Although the health of this part of the state is not so good as that of the western part, no great difficulty is experienced on this account.

Above Battle's the river is sluggish for some distance, after which the fall becomes considerably greater. On the upper part of the river there are only saw- and grist-mills, and there are no sites of importance not used, although on the upper part of the stream, and on its tributaries, there are many places where power could be obtained by damming.

Between Mr. Battle's and Louisburg there are two small grist-mills and gins; the lower one a small mill with 8 feet fall, the dam being 215 feet long and 6 feet high, built of wood, at a cost of $600, and throwing the water back 1½ miles; and the upper one, that of Mr. N. R. Strickland, a saw- and grist-mill, with a dam of wood and stone 180 feet long, 7 feet high, and costing $1,000, and backing the water 7 miles, with an average width of 150 feet. At this mill a fall of 7 feet is used, and about 50 horse-power, net, with a waste of water all the time, except in times of extreme drought.

At Louisburg Col. J. F. Jones has a saw- and grist-mill using 8 feet fall and running full capacity all the time, with water wasting. The dam is of rock, 250 feet long and 8 feet high, throwing the water back 2 miles, with an average width of 150 feet; a power of about 65 or 75 horse-power is said to be used.

Above this there are no mills of importance. It will be seen that the water-power of the Tar river does not amount to much, being almost all obtained by damming, and there being no fall of any consequence except that at Battle's.

Tar river—Summary of power.

Locality.	Distance from Tarboro'.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross. †				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. ms.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*						*Feet.*		
Battle's mills	20±	768						20	2,800	280	340	1,536	384	235	16.83	133	Only natural fall on river.
Vivaratti's mill	34±	615	12	14	10	11	47	8	....	80	100	480	115	....	8.00	....	Mill at dam.
Strickland's mill	46±	565						7	....	66	85	390	97	50	7.00	150	
Louisburg	75±	383						8	....	45	60	300	69	60	8.00	....	
*Between head of Battle's	28±	768															
shoal,			12	14	10	11	47	110±	*Miles.* 60±	970	1,200	5,700	1,375	....	23.00	....	
and Raleigh and Gaston																	
railroad	90±	270															

* These figures are too inexact to be of any practical value, and moreover these amounts of power are not practically available.
†See pages 18 to 21.

TRIBUTARIES OF THE TAR RIVER.

Fishing creek is the first important tributary met with in ascending the stream. It rises in Warren county, forms for some distance the boundary-line between Halifax, on the north, and Nash and Edgecombe on the south, and empties into the Tar in the latter county. Its length, measured in a straight line, is about 50 miles, and its drainage area 760 square miles. Its only tributary worth mentioning is Little Fishing creek, which enters from the north. The stream crosses the fall-line near Enfield, and the general character of its drainage-basin is the same as that of the Tar river. The water-power of the stream is not extensive, and is used for saw- and grist-mills, cotton-gins, and one cotton factory.

The first power is that of Dr. J. T. Bellamy, at the fall-line, 4 miles from Enfield, where there are a saw- and grist-mill, gin, and cotton-yarn mill. The dam is of stone, built in 1857, at a cost of $9,000, and is 160 feet long

and 12 feet high, backing the water about 3 miles, and overflowing some 200 acres of swamp-land to an average depth of perhaps 7 or 8 feet. At one end of the dam is the cotton factory, and at the other the saw- and grist-mills, all using a fall of 12 feet and a total of about 50 horse-power, of which the factory uses perhaps 30, with a turbine-wheel, and with always a waste of water. The drainage area above this place being about 500 square miles, and the rainfall 47 inches, I would judge the available power to be at least 100 horse-power in the low season of dry years, 125 in the low season of ordinary years, and twice that amount, or more, during nine months—these powers being gross, but doubtless capable of being increased to a very large extent by drawing down the water in the pond during working hours. This site is 4 miles from the railroad.

The next power is that of William Burnett, 6 miles west of the railroad, at Millbrook. The dam is wood (crib-work), filled with stone, 260 feet long and 8 feet high, backing the water about three-fourths of a mile, but not throwing it out of its banks. A race 60 feet long leads to the mill—a grist- and saw-mill—where a fall of 5 feet (?) is used. The amount of water in the stream here is probably about the same as at Bellamy's. If the available fall is 8 feet, the available power is therefore about two-thirds of that at the latter place. The bed of the river here is rock, and very favorable for a dam.

The remaining powers on this creek and its tributaries are not worthy of special mention. They are included in the table below. The grist-mills generally have one, two, or three run of stones.

On the whole, as far as could be ascertained, the stream is not of much value for water-power, on account of its small fall and its variable flow. I heard of no good sites not used, but there are probably places where a certain amount of power could be obtained by damming.

Swift creek rises in Warren and Granville counties, where it is called Sandy creek; flows through Franklin, Nash, and Edgecombe, joining the Tar about 7 miles above the mouth of Fishing creek, its length, in a straight line, being about 50 miles, and draining an area of about 350 square miles. In general character it is similar to Fishing creek, but is said to be more sluggish, and to have lower banks. Its water-power is not valuable, and I heard of no sites not occupied. The power utilized will be found in the table. The mills are saw- and grist-mills, cotton-gins, and one cotton-yarn factory, at Laurel, belonging to Col. J. F. Jones. The latter is the most important of the utilized powers. The dam is of wood and stone, 100 feet long, 5 feet high, backing the water one mile, and giving a fall of 12 feet, with a race 60 feet long. The power is used for a grist- and saw-mill, and for a cotton-yarn factory, with 612 spindles, using perhaps, in all, 30 or 40 horse-power.

The remaining tributaries to the Tar river are of no importance, and the only mills on them are small saw-mills and grist-mills with one or two run of stones. The smaller streams nearly dry up in summer, and many of the mills have to stop grinding. The table for the utilized power of the Tar and its tributaries is compiled from the returns of the enumerators:

Table of power utilized on Tar river and its tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
Tar river	Pamplico river	North Carolina	Nash	Cotton factory	1	17	155
Do	do	do	do	Flour and grist	3	29½	85
Do	do	do	do	Saw	1	12	50
Do	do	do	do	Cotton-gin	3	27	22
Do	do	do	Franklin	Flour and grist	1	9	40
Do	do	do	do	Saw	1	9	25
Do	do	do	Granville	Flour and grist	6	90	153
Do	do	do	do	Saw	5	65	98
Fishing creek	Tar river	do	Halifax	Cotton factory	1	12	30
Do	do	do	do	Flour and grist	2	19	40
Do	do	do	do	Saw	2	19	40
Do	do	do	Warren	Flour and grist	7	100	148
Swift creek	do	do	Edgecombe	do	1	7	30
Do	do	do	Nash	do	2	19	35
Do	do	do	Franklin	do	3	30	53
Do	do	do	do	Saw	1	12	15
Do	do	do	do	Cotton factory	1	12	20
Do	do	do	Warren	Flour and grist	6	90	211
Other tributaries of	do	do	Pitt	do	4	29	74
Do	do	do	do	Saw	2	14	84
Do	do	do	Edgecombe	Flour and grist	3	35	75
Do	do	do	do	Saw	2	......	49
Do	do	do	Halifax	Flour and grist	4	62	67
Do	do	do	Nash	do	4	27	96
Do	do	do	do	Saw	1	8	12
Do	do	do	do	Agricultural implements.	1	8	12

PERSON
ROXBORO
GRANVILLE
ORANGE
HILLSBORO
N.C. R.R.
Little Riv.
Flat R.
Eno R.
FRANKLIN
NASH
WAKE
RALEIGH
Paper Mills
Milbourny
RALEIGH & GASTON R.R.
RALEIGH & AUGUSTA R.R.
NORTH CAROLINA R.R.
Little River
JOHNSTON
SMITHFIELD
Dowell
Moccasin Cr.
Rocky Mt.
WILSON
WILDON R.R.
WAYNE
GOLDSBORO
GREENE
SNOWHILL
PITT
LENOIR
KINSTON
Neuse River
WILMINGTON
Swamp
Trent River
JONES
NEWBERNE
CRAVEN
PAMLICO
BEAUFORT
N
S
W
E
Scale of Miles.
0
5
10
20
30
40
50

Table of power utilized on Tar river and its tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
Other tributaries of	Tar	North Carolina	Nash	Cotton-gin	1	7	4
Do	do	do	Franklin	Flour and grist	14	234	251
Do	do	do	do	Saw	9	135	163
Do	do	do	do	Cotton-gin	2	22	18
Do	do	do	do	Leather	1	15	10
Do	do	do	Warren	Flour and grist	[illegible]	106	112
Do	do	do	do	Saw	1	15	20
Do	do	do	Granville	Flour and grist	11	133	186
Do	do	do	do	Saw	6	91	108

IV.—THE NEUSE RIVER AND TRIBUTARIES.

Drainage-basin of the Neuse river, North Carolina.

DRAINAGE AREAS.

	Square miles.
Neuse river, at mouth	5,299
Neuse river, at New Berne	4,250
Neuse river, at Goldsboro'	2,451
Neuse river, at Smithfield	1,317
Neuse river, at Milburny	995
Neuse river, at paper-mill	890
Contentnea creek, at mouth	991
Little river, at mouth	326
Little river, at Lowell	195
Flat river, at mouth	166
Little river, at mouth	130
Eno river, at mouth	134

THE NEUSE RIVER.

The Neuse river is formed in the northwest corner of Wake county, North Carolina, by the union of three small streams, the Eno, Flat, and Little rivers, which themselves take their rise in Person and Orange counties. The Neuse flows in a general southeasterly direction through Wake, Johnston, Wayne, Lenoir, and Craven counties, emptying into Pamlico sound below New Berne, its general course, in its lower and navigable portion, being more nearly east. It forms for a short distance the boundary between Granville and Wake counties, and, near its mouth, between Lenoir, Pitt, and Pamlico on its left and Craven on its right. Its length above New Berne, measured in a straight line, is about 150 miles, but it is much greater following the river, which is very tortuous in places. The principal towns on the stream are New Berne (population 6,443), Kinston (population 1,216), Goldsboro' (population 1,933), Smithfield, and Hillsboro', the last being on the Eno. The head of navigation on the river is Smithfield, about 160 miles above New Berne, and the government is now engaged in improving the river up to this point. At present there is a navigable depth of 3 feet as far as Goldsboro' ($97\frac{1}{2}$ miles above New Berne) during eight or nine months of the year.

The area drained by the Neuse comprises about 5,300 square miles. That part above New Berne measures about 4,250 square miles. The principal tributaries of the river enter from the north, viz: the Contentnea creek (mouth about 30 miles above New Berne) and Little river (mouth just above Goldsboro', $97\frac{1}{2}$ miles above New Berne), draining, respectively, about 990 and 325 square miles, approximately. The river crosses the fall-line near Smithfield, and below that point there is no water-power. The fall at Smithfield, however, is not very great, and the fall-line is less prominent than in the case of the Roanoke and the Tar, the ledge of rock, forming the falls at Weldon and Rocky Mount, showing itself only very slightly on the Neuse.

Below Goldsboro' the river flows through a low, heavily-timbered country, and is very like the Roanoke in general character. The soil is alluvial—clay, sand, and marl; the banks from 3 to 20 feet high; the country covered with extensive pine forests and cypress swamps, and the staple product cotton. Some of the bottoms have been reclaimed by the use of dikes. Below Contentnea creek the banks and adjacent bottoms are only a few inches above low water, and the floods reach a height of 12 feet, covering large areas. The channel is very tortuous, cut-offs are often formed, and the navigation difficult. Above Smithfield the drainage-basin presents no peculiarities that have not been referred to in speaking of the Roanoke and Tar. The map will show its form and dimensions.

In the upper part of the valley a fine quality of granite is quarried, and in the lower part, not far above New Berne, a marl is found which is said to be a very good building-stone, being quite soft when quarried, but becoming very hard on exposure. In fact, there is no lack of building material in the valleys of the Neuse, Tar, or Roanoke.

As regards bed, banks, and freshets, the river is similar to the Roanoke, except that the bottoms are said to be less extensive (above Smithfield) and the freshets not so sudden nor violent, seldom endangering dams. Trouble with ice is very rare. There are no lakes or artificial reservoirs, but there are facilities for the latter on the upper tributaries.

The rainfall is 47 inches—12 in spring, 14 in summer, 10 in autumn, and 11 in winter, approximately.

The fall of the river below Smithfield is very small, its elevation at that point being in the neighborhood of 100 feet. At the crossing of the Raleigh and Gaston railroad, some 35 miles farther up, the elevation is about 170 feet, making the fall between those points at the rate of 2 feet to the mile. Professor Kerr states that the total fall, from the northwest corner of Wake county, about 32 miles above the railroad crossing, to tide, is about 340 feet; it seems, however, scarcely probable that the fall in these 32 miles can be at the rate of 5.3 feet to the mile.

WATER-POWERS.

The first site for power in ascending the river is at Smithfield, at the fall-line, and it is said that there was once a mill there, although it is now gone. Although some power might be obtained at the place, the site is not a favorable one. The river at Smithfield is 130 feet wide.

The next site, and the first one of importance, is at Milburny or Neuse mills, about 25 miles above Smithfield and 6 or 7 miles from Raleigh, formerly improved, but at present idle. The available fall here is about 12½ feet, with a dam 8 feet high and a race 150 feet long. Such a dam, it is said, would pond the water for several miles. It is evident, therefore, that the fall here is not very pronounced, and it seems strange that there is no large fall on the river below this point. It seems probable, moreover, that power might be got below by damming, but it is said that there are no favorable places where a dam could be built without trouble by overflowing land above. At Milburny the bed is solid rock, very favorable for a dam, and the race had to be blasted out. The banks are abrupt on the right, but not so much so on the left, and the location is said to be a safe one. The power was formerly used by a paper-mill on the left bank and a grist- and saw-mill on the other, the fall utilized being 12½ feet; but the paper-mill was burnt, and the dam, not being taken care of, is gone. The building of the grist- and saw-mill is still standing, although it is about five years since any power has been utilized. It is expected, however, that the power will be again utilized in a short time.

The drainage area above this site is about 1,000 square miles. Professor Kerr gauged the river at low water, and found the flow to be about 193 cubic feet per second, giving a power of 22 horse-power per foot fall. Estimates of the flow and power, according to methods already referred to, result as follows:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow, per second.	Horse-power, gross.	Horse-power, gross.
	Sq. miles.	*Feet.*	*Cubic feet.*	*Per foot fall.*	*Per 12½ feet fall.*
Minimum	1,000	12½	160	18.2	227
Minimum low season			175	20.0	250
Maximum, with storage			750	85.2	1,065
Low season, dry years			190	21.8	272
"Low water", Professor Kerr			193	22.0	275

By storing the water during the night this power could be greatly increased, but whether such storage would be practicable I cannot say, not knowing the dimensions of the pond.

This power, as before remarked, is 6 or 7 miles from Raleigh, from which point railroads diverge in four directions.

The next power on the river is the paper-mill of the Falls of Neuse Manufacturing Company, leased to W. F. Askew. Between this power and Milburny there was formerly an oil-mill, but the dam is said to have caused so much trouble by overflow, and so much sickness in the vicinity, that the property was purchased by the neighbors, and the mill torn down. Mr. Askew's paper-mill is at Falls of Neuse, 3 miles above the Raleigh and Gaston railroad, and 13 miles north of Raleigh. The dam, which extends entirely across the river, is of wood, about 400 feet long and 6 feet high, backing the water about 10 miles, the depth averaging perhaps 8 feet. A race 1,000 feet long leads to the mill, where there is a fall of 17 feet. The power used is 100 horse-power, used for the paper-mill and for a grist-mill, saw-mill, and cotton-gin, but this power can only be obtained during eight months of the year, owing to leakage, etc. There is little trouble with high water.

The drainage area above this place is about 890 square miles, and the rainfall 42 to 44 inches. Hence the power available, per foot, would be about eight-tenths of that at Milburny, or, in round numbers, as given in the following table:

*Table of power at Falls of Neuse.**

State of flow.	Drainage area.	Fall.	Flow, per second.	Horse-power.	Horse-power.
	Sq. miles.	*Feet.*	*Cubic feet.*	*Per foot fall.*	*Per 17 feet fall.*
Minimum	890	17	128	14.5	245
Minimum low season			140	15.9	270
Maximum, with storage			665	75.5	1,283
Low season, dry years			152	17.2	292

Above this mill there are no powers of importance on the river so far as I could learn. It seems strange that such a large and long river should offer so little power, especially in a section of country which abounds so largely in water-power. The fact that there is no power on the fall-line is also remarkable.

The following table gives a summary of the powers on the river utilized and available:

Neuse River—Summary of power.

Locality.	Distance from head of navigation.	Drainage area.	Rainfall. Spring.	Rainfall. Summer.	Rainfall. Autumn.	Rainfall. Winter.	Rainfall. Year.	Total fall. Height.	Total fall. Length.	Horse-power available, gross.† Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Total utilized. Fall.	Total utilized. Horse-power, net.	Per centum of minimum utilized.
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Miles.*					*Feet.*		
Milburny	25	1,000						12½	....	227	250	1,065	272	0	0	0
Falls of Neuse	38	890						17	....	245	270	1,283	292	17	100	65
Between Raleigh and Gaston railroad	35	900	11	13	10	10	44									
and Smithfield	0	1,317						70	35	1,400*	1,540*	6,550*	1,680*	0	0	0

* Practically of no value, and, in fact, not available.

† See pages 18 to 21.

TRIBUTARIES OF THE NEUSE RIVER.

Most of the utilized power in the drainage-basin of the Neuse is located on its tributaries, although none of them are large enough to afford very large powers.

The first important one met with in ascending the Neuse is the Trent river, which joins the Neuse at New Berne. The drainage-basin of the Trent, lying entirely below the fall-line and presenting no water-power of importance, need not be further considered.

The next important tributary is Contentnea creek, from the north, draining an area of about 990 square miles, and joining the Neuse about 30 miles above New Berne. This stream has its sources above the fall-line, in Franklin county, where it is called Moccasin creek; thence, flowing in a southeasterly direction, it forms the boundary-line between Franklin and Nash counties on the north and Wake and Johnston on the south, flows through Wilson and Greene counties, and finally joins the Neuse, after forming for 6 or 7 miles the boundary between Pitt and Lenoir counties. It crosses the fall-line, in Wilson county, about at the point where it changes its name to Contentnea; but, as in the case of the Neuse, there seems to be no decided fall in the stream at this point. Above the fall-line it partakes of the general character of Swift and Fishing creeks, previously described, and it affords no water-power of much importance, the declivity being gradual. There is probably power available on the stream which can be utilized by damming at suitable places, but no particular sites for powers were brought to my notice. The tributaries of the Contentnea are not of much importance.

The next important tributary is Little river, which rises in Franklin, flows southeast through Wake and Johnston, joining the Neuse in Wayne county 2 or 3 miles above Goldsboro', and draining an area of about 325 square miles, the length of the stream, in a straight line, being nearly 60 miles. The drainage-basin is long and narrow, and the

* See pages 18 to 21. According to all I can learn regarding this power, I am inclined to regard these estimates as too large, being informed that it is sometimes only possible to run a grist-mill in summer for several weeks at a time. But the dam is very leaky, and it may be that there are other sources of loss. Only an examination of the place can tell.

tributaries of no consequence. The stream crosses the fall-line, but, as in the case of the Neuse, no particular fall occurs at that place. The products of the basin are principally corn, cotton, cereals, vegetables, and fruits, and the soil fertile, generally sandy and loamy. The general character of the stream does not differ from that of the tributaries of the Tar. The banks are often low and subject to overflow, and the bed is generally of soft material—mud, sand, etc. The declivity is quite uniform, and no important sites for power could be learned of. There is some power already utilized, the most important mill being the cotton factory of William Edgerton, at Lowell, about where the stream crosses the fall-line, and some 25 miles from its mouth. The power at this place is supplied by a wooden dam, built some thirty-three years ago, about 80 feet long and 10 feet high, backing the water 4 miles, with an average width of 150 feet and an average depth of 6 feet. The fall used is 10 feet, and the number of horse-power 40, which can be obtained at all seasons of the year. The drainage area above the place being about 195 square miles, and the rainfall about 48 inches, I have estimated the minimum and the low-season flow in dry years at about 18 and 25 cubic feet per second, respectively, and the available power, with a fall of 10 feet, at 20 and 28 horse-power. With storage during the night these figures could be increased, and this may easily be done if the pond is as large as given above. Above the Lowell factory, on Little river, are only small saw- and grist-mills. The water-power of the stream may be said to be, in general, of little value.

In the neighborhood of Goldsboro' there are several small spring streams which are said to afford quite constant powers, but none of them have sufficient capacity to run any but very small mills. Such are Sleepy creek (mouth 10 miles below Goldsboro') and Falling creek (mouth 10 miles above the railroad bridge). On these streams large storage can generally be obtained, and the power resulting from the natural flow could be doubled by being concentrated into twelve hours.

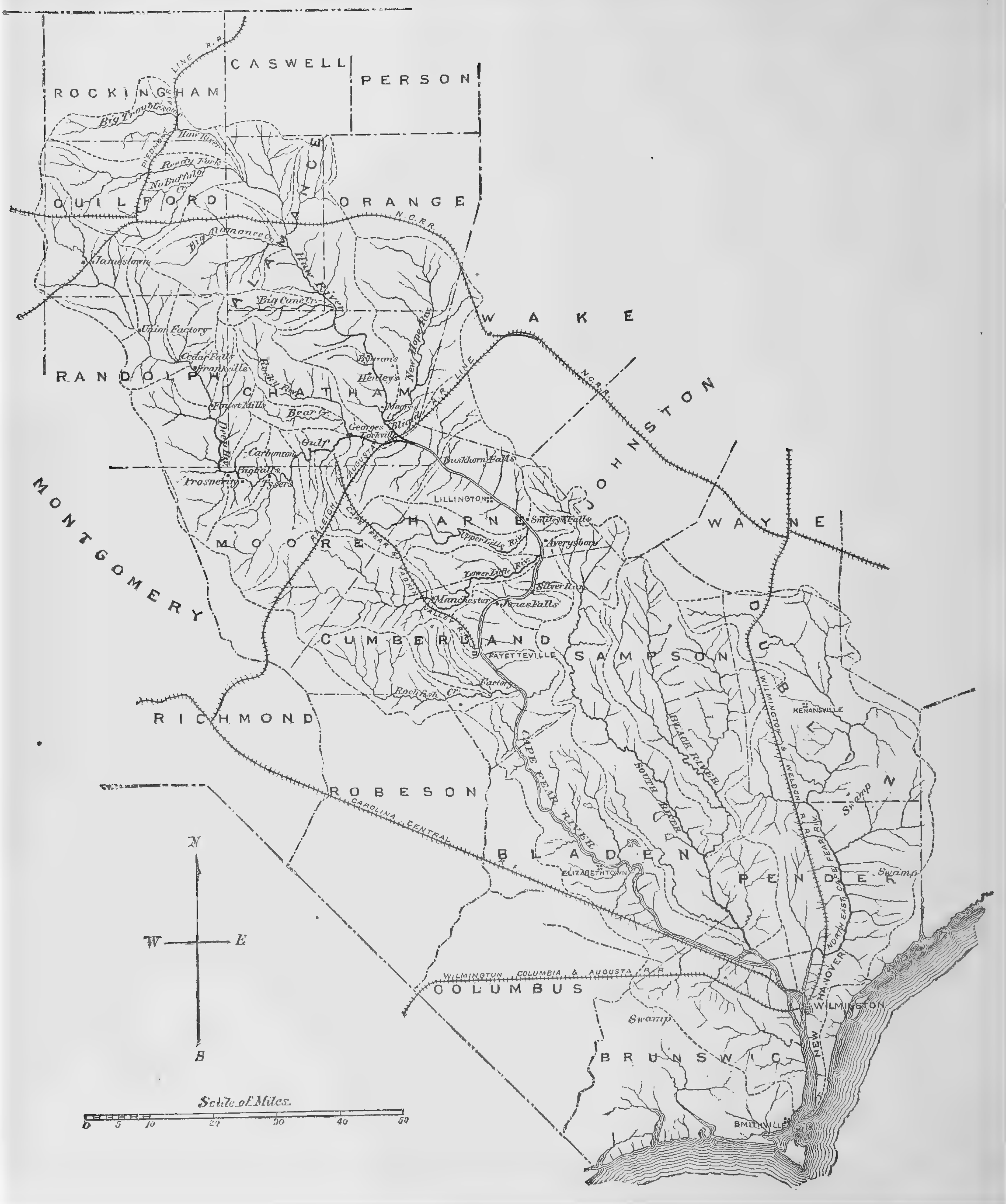
The other tributaries of the Neuse below the junction of its three headwaters have numerous small grist- and saw-mills and occasionally a paper-mill, all of which are here tabulated. Most of these mills have to stop during the summer on account of low water.

The most northerly of the three headwaters referred to is the Flat river, which rises in Person county and flows southeast through a corner of Orange, having a total length of some 25 miles in a straight line. It drains an area of about 166 square miles, being the largest of the three streams, has a considerable fall, and is well suited for the development of small powers. The power utilized is given in the table. The power available I cannot estimate; neither could I obtain information regarding any particular sites not used.

Little river is the second of the three headwaters. Rising in Orange county, with perhaps a few branches in Person, and flowing a little south of east through the northern part of Orange, with a total length, in a straight line, of some 20 miles, it drains an area of about 130 square miles. None of these streams are very tortuous. Little river has the same general character as Flat river, and its power is utilized by saw- and grist-mills, and by one cotton factory—the Orange factory. The power at this place is obtained by a dam of stone and wood, 270 feet long and 14 feet high, built at a cost of $1,500, and affording a fall, at the factory, of 17½ feet and furnishing a 40 horse-power. In summer there is no waste of water, but in winter it generally flows over the dam. I estimate the flow of this stream at its mouth to be at a minimum about 8, and at its low-season flow, in dry years, 12 cubic feet per second, giving powers of 16 and 24 horse-power, with fall of 17½ feet. I judge, therefore, that the pond at Orange factory is sufficiently large to store the water during the night if they succeed in getting full capacity all the time. The above estimate, however, may, of course, be far from correct.

The most southerly of the three headwaters of the Neuse is the Eno, rising in the northwest corner of Orange county, flowing first nearly south and then nearly east through the county, having a length of about 25 miles in a straight line, and draining an area of about 134 square miles. It is similar in character to the others, and its power is used only by grist- and saw-mills, some of which are obliged to stop in the summer. At Hillsboro' the stream is about 50 feet wide, and will probably afford not more than 8 or 9 cubic feet per second in dry years during the low season, and probably less, or about 1 horse-power per foot fall. The utilized power is given in the table.

It will be seen that the Neuse river possesses a small amount of water-power for a stream of its size in this part of the country. The lower parts of the river and the tributaries below the Raleigh and Gaston railroad are not very favorable for power—the river on account of its gradual fall and low bank, and the tributaries because of the considerable variability in their flow. Exceptions are found in the case of some tributaries not far below the fall-line, which are fed by springs and keep up quite well during the summer, belonging, in fact, to the class of sand-hill streams, of which we shall meet more noticeable examples in the case of the tributaries to the Cape Fear and Yadkin. The tributaries in the upper part are more favorable, have a greater fall, higher banks, and are probably not so variable in their flow. Still, there are no such sites for power on the Neuse river as are found on the Roanoke, Tar, or on streams farther south.


ROCKINGHAM
CASWELL
PERSON
GUILFORD
ORANGE
ALAMANCE
WAKE
RANDOLPH
CHATHAM
JOHNSTON
MONTGOMERY
MOORE
HARNETT
WAYNE
CUMBERLAND
SAMPSON
DUPLIN
RICHMOND
ROBESON
BLADEN
PENDER
COLUMBUS
BRUNSWICK
NEW HANOVER
N.C.R.R.
Jamestown
Big Cane Cr.
Union Factory
Cedar Falls
Franklinville
Lockville
Buckhorn Falls
LILLINGTON
Averysboro
Manchester
FAYETTEVILLE
KENANSVILLE
Black River
South River
Cape Fear River
ELIZABETHTOWN
CAROLINA CENTRAL
WILMINGTON COLUMBIA & AUGUSTA R.R.
WILMINGTON
SMITHVILLE
N
S
W
E
Scale of Miles
0
5
10
20
30
40
50

Neuse river and tributaries—Table of power utilized.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Neuse river	Pamlico sound	North Carolina	Wake	Paper	1	17	80
Do	do	do	do	Flour and grist	1	10	20
Do	do	do	do	do	1	8	20
Contentnea creek (Moccasin)	Neuse river	do	Wilson	do	3	23	79
Do	do	do	do	Saw	2	16	60
Do	do	do	do	Cotton-gin	1	6	8
Do	do	do	Johnston	Flour and grist	2	17	107
Do	do	do	do	Saw	1	12	70
All tributaries to	Contentnea creek	do	Greene	Flour and grist	6	63	145
Do	do	do	Wilson	do	6	43	100
Do	do	do	do	Saw	2	16	45
Do	do	do	do	Cotton-gin	3	32	48
Do	do	do	Wayne	Flour and grist	2	17	12
Do	do	do	do	Saw	1	8	18
Do	do	do	Nash	Flour and grist	2	......	22
Do	do	do	do	Saw	2	......	22
Little river	Neuse river	do	Johnston	Flour and grist	2	14	77
Do	do	do	do	Saw	2	16	40
Do	do	do	do	Cotton factory	1	10	40
Do	do	do	Wake	Saw	1	14	16
All other tributaries to	do	do	Wayne	Flour and grist	4	50	120
Do	do	do	do	Saw	1	10	10
Do	do	do	do	Woolen	2	......	......
Do	do	do	Johnston	Agricult'l implements	1	8	20
Do	do	do	do	Flour and grist	13	133	206
Do	do	do	do	Saw	3	39	36
Do	do	do	Pamlico	Flour and grist	1	8	20
Do	do	do	Jones	do	3	39	70
Do	do	do	Craven	do	1	8	4
Do	do	do	do	Cotton-gin	1	......	......
Do	do	do	Lenoir	Flour and grist	3	27	86
Do	do	do	Wake	do	23	309	397
Do	do	do	do	Saw	8	120	133
Do	do	do	do	Woolen	1	......	15
Do	do	do	Franklin	Flour and grist	1	20	15
Do	do	do	Granville	do	3	49	72
Do	do	do	do	Saw	1	18	30
Flat river and tributaries	do	do	Orange	Flour and grist	4	50	100
Do	do	do	do	Saw	1	12	20
Do	do	do	Person	do	5	61	145
Do	do	do	do	do	5	......	125
Little river and tributaries	do	do	Orange	do	4	55	48
Do	do	do	do	do	6	86	90
Do	do	do	do	Box	1	......	6
Do	do	do	do	Cotton factory	1	17	40
Eno river and tributaries	do	do	do	Flour and grist	18	271	358
Do	do	do	do	Saw	4	60	55

V.—THE CAPE FEAR RIVER AND TRIBUTARIES.

THE CAPE FEAR RIVER.

This river, formed by the junction of the Haw and Deep rivers in Chatham county, North Carolina, flows in a southeasterly direction through Harnett, Cumberland, Bladen, and Brunswick counties, and for a short distance between Brunswick and New Hanover, and empties into the Atlantic at Cape Fear. Its length, in a straight line, is about 125 miles, and by the river about 192. The principal towns on the stream are Wilmington, 30 miles from the mouth (population 17,361); Elizabeth, the county-seat of Bladen county; Fayetteville, the county-seat of Cumberland county (population 3,485); Averysboro', and Lillington (the county-seat of Harnett county)—the two latter being small towns of a few hundred inhabitants. Fayetteville is the head of navigation for steamers of light draft, its distance from the sea being 160 miles by the course of the stream. Considerable money has been, and is being, spent by the government for the improvement of the navigation of the river below Wilmington, which is a port of the entry, and present project contemplates the securing of a navigable depth of 12 feet at mean low water up to

that city; but by taking proper advantage of the tides 14½ feet can be carried up to that point. The average range of the tides at Smithville, at the mouth of the river, is about 4 feet. The entrance across the bar to the harbor at Smithville can be made by vessels drawing 17½ feet at spring-tides.

By a series of locks and dams the river was formerly made navigable up to the confluence of the Haw and Deep rivers, and the works were carried for some distance up the Deep river. These old navigation works, like those on the Roanoke, were never successful from a financial point of view, and before long went into disuse, and were abandoned. Some ten years ago, however, a part of the works were again put in order, and navigation again opened between Battle's dam and Carbonton, and kept open for several years successfully. But at present they have again passed into disuse, and although the last company which operated them is still in existence they are practically abandoned so far as navigation is concerned.*

The total area drained by the Cape Fear is about 8,400 square miles, of which the Deep river drains 1,350, the Haw river 1,675, and the Cape Fear proper 5,375. The principal tributaries of the river below the forks are: From the east, in order as the river is ascended, the Northeast Cape Fear river, draining 1,330 square miles, and entering the Cape Fear about 20 miles above its mouth; the Black river, draining about 1,430 square miles, and joining the main stream about 30 miles from its mouth; and from the west, in the same order, Rockfish creek, draining 280 square miles, and emptying 10 miles below Fayetteville; Lower Little river, draining 448 square miles, and emptying about 25 miles above Fayetteville; and Upper Little river, draining about 176 square miles, and emptying about 30 miles above Fayetteville.

The drainage-basin of the Cape Fear proper, without the basins of the Deep and Haw, resembles that of the Roanoke. The river is crossed by the fall-line near Averysboro', about 27 or 28 miles above Fayetteville, giving rise to Smiley's falls, which is yet to be described. The map of the basin will show its form and general dimensions. The elevations of the water-sheds between the Cape Fear and the adjacent rivers are not very great, and the tributaries do not afford much power, except in places where, by damming, the water can be thrown back for considerable distances and considerable storage-room obtained; but the fall of the tributaries is, on the whole, small. As regards soil, vegetation, and building material, the drainage-basin of the Cape Fear resembles that of the Roanoke, and need not be described. The facilities for storage in that part below the junction of the Haw and Deep rivers will probably be found to be not very good on account of the flatness of the country, and, in places, of the porosity of the soil—resembling in this respect, also, the Roanoke. Further up, in the valleys of Deep and Haw rivers, the storage facilities are better. As regards bed, banks, and freshets, the stream very closely resembles the Roanoke, although the bottoms are said to be not quite so extensive as on the latter river. Above Averysboro' the river flows through an alluvial country, with banks generally low, and a width of from 400 to 600 feet. Below Averysboro' the river is narrow, the banks high, and the soil sandy.

The rainfall on the basin of the Cape Fear is about 46 inches—12 in spring, 13 in summer, 10 in autumn, and 11 in winter; but in the valleys of the Deep and Haw rivers, although the total rainfall remains the same, the summer-fall is rather smaller, and that in winter remains about the same. It would seem to follow from these facts that the flow of the Cape Fear becomes proportionately more variable as it is ascended. Another cause which tends to make the flow of the river variable is the fact that the courses of many of its tributaries in Chatham county lie in a slaty and broken region, which sheds the water with great rapidity, so that these streams become almost dry in summer; and this cause also contributes to increase the suddenness and violence of the freshets. The freshets on the Cape Fear, indeed, are said to be more violent than on any other North Carolina river. On the lower part of Deep river the banks are often overflowed, sometimes to a depth of 10 or 12 feet, and much injury is thereby done to the crops. For the upper 30 miles of the Cape Fear the banks are low and the river wide, so that the rise does not

*The Cape Fear Navigation Company was first chartered by the state in 1796, with a capital of $80,000. In 1815 additional privileges were granted, and authority given to increase the capital stock to $100,000. Although the money was expended, no useful result was accomplished, and in 1848–'49 a new company was organized, with a capital of $200,000, which was afterward increased to $350,000, the state subscribing three-fifths of the whole amount. Surveys were made, but the cost of the works which were entered upon exceeded the estimates, and although a steamer did once pass over the whole route between Fayetteville and Carbonton, on Deep river, the company was never able to keep the locks and dams in a condition requisite to secure uninterrupted communication. The failure of these works was partly due to bad engineering in the location of the dams, it being difficult to secure their ends against the action of freshets. The amount expended by the last company was about $350,000. (Annual Report Chief of Engineers, 1873, pp. 743–'4.) The work was finally abandoned when the war broke out, and subsequently the works were in a measure destroyed, in part by natural causes, and in part intentionally. In 1868 the state appropriated the works to the Raleigh and Augusta Air-Line railroad (then Chatham railroad), but they were afterward bought by some parties who organized as the Deep River Manufacturing Company. A little later, the Lobdell Car-wheel Company having bought an interest in the company, and also the Endor furnace, the works were again put in order from Battle's dam up, in the years 1872 to 1874, for the purpose of supplying the Endor furnaces with the Buckhorn ore, for which there was no convenient transportation except by water. Navigation was kept open for several years successfully, and may be said to be still open between Lockville and Carbonton, although the company has carried on no traffic since 1876. In that year the Deep River Manufacturing Company was consolidated with the Cape Fear Iron and Steel Company, under the new name of "The American Iron and Steel Company," which company is still in existence; but the furnaces were stopped, owing to the depression in the iron business, and this, of course, put an end to the navigation, which was confined to that carried on by the company, no local trade having been built up, the single steamboat owned by the company being no more than sufficient for their own wants. Since 1876 the boat has been run whenever a paying trip could be made, but not regularly, and no trips have been made since 1880.

exceed 20 feet; but in the succeeding 75 miles, where the banks are high and the stream narrow, the rise is very great, amounting occasionally to 65 feet at Fayetteville. These freshets constitute a serious disadvantage to the use of water-power on the stream. There is, however, no trouble at all with ice. I could find no gaugings of the river, and am therefore again obliged to resort to estimates regarding flow and power.

The following table shows the declivity of the stream:

Cape Fear river—Table of declivity.

Locality.	Distance from Wilmington.	Elevation above tide.	Distances between points.	Fall between points.	Average fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Junction of Haw and Deep rivers*	172.0	130			
			29.5	61	2.060
Head of Smiley's falls	142.5	69			
			3.5	27	7.710
Foot of Smiley's falls	139.0	42			
			27.0	35	1.250
Fayetteville	112.0	7(?)			
			112.0	7	0.062(?)
Wilmington	0.0	0			

* At crossing of Raleigh and Augusta Air-Line railroad. This and the other elevations on the road are due to Major Winder, general superintendent.

The principal products of the region along the Cape Fear are corn, cotton, peanuts, potatoes, pease, rice, various vegetables and fruits, rye, oats, wheat, and grasses. The whole of this region lies in the cotton-belt.

The mineral resources of this region, especially of the upper part, are very great. Coal and iron are very abundant, but, owing to difficulties of transportation, the mines have been little worked. The coal-fields along the Deep river have been estimated by Emmons to cover an area of 90 square miles, and to contain at least 258,000,000 tons, easily workable. The coal is bituminous, and of superior quality. At Egypt, on Deep river, a shaft was excavated to a depth of 460 feet previous to 1850, but operations were suspended on account of want of transportation. Iron has been found at Ore Knob, about 9 miles from the Gulf, and at Buckhorn, on the east bank of the Cape Fear, 8 miles below the forks; and all the way up through the valleys of the Haw and Deep rivers iron-ore of excellent quality has been found in large quantities. Copper-ore has also been found in the same region, and several mines have been worked.

The basin of the Cape Fear is not very thickly populated, and its population has not increased much since 1870. In that year the population per square mile was 22.7, while now it is only 28.4. (Census Bulletin No. 78, by Mr. Gannett, geographer of the Census.)

I proceed to describe the river more in detail and to discuss its water-powers, commencing at its mouth.

Below Wilmington there is, of course, no power. The country is low and very swampy, and large quantities of rice are raised. The river is, in places, over a mile wide, and at the mouth the width is 3 miles. The country is also swampy for 50 miles above Wilmington; there is no power, and rice is the principal product. Thence up to Fayetteville the banks are from 15 to 40 feet high, the bed entirely sand, and the navigation difficult, on account of shifting sand-bars.

The first dam of the old Navigation Company was at Jones' falls, 7.73 miles above Fayetteville, its height having been about 5 feet. It is not a good site for power.

The second dam was at Silver run, 17.11 miles above Fayetteville, its height having been probably greater, as its crest was 15.64 feet above that of the Jones' falls dam. It was not spoken of as a good site for power.

The third dam was at Williams' fish-trap, 25 miles from Fayetteville. The total fall from the top of the dam to low water at Fayetteville was 25.74 feet. Not a good site.

The fourth dam was at Haw Ridge, 27 miles above Fayetteville; height of crest above Fayetteville (low water), 34.97 feet. Not a good site. None of the dams thus far mentioned are now in existence.

Up to this point the fall of the river is slight, and its general character similar to what it is for some distance below Fayetteville. We now come to the fall-line, where the river passes from the middle to the eastern division over a long shoal known as Smiley's falls. In the table of declivity I have already stated that the fall extends through a length of about $3\frac{1}{2}$ miles, with a total fall of about 27 feet. There were three dams built on these falls, viz: Green Rock, Big Island (Narrow Gap), and Sharpfield, the latter being at the head of the falls, and all of which have been completely carried away. The table following, on page 60, will show their distances from Fayetteville, and the height of their crests above the datum. "At Narrow Gap a ledge of rocks from 4 to 6 feet above the ordinary bed extends nearly across the river, leaving a narrow opening near the left bank, whence comes the name. The whole volume of water, during ordinary stages, passes through this gap."* Smiley's falls, really the first power on the river, none of those below being worth anything as powers, are situated above the mouth of Upper Little river, and about 20 miles from any railroad. The bed is rock, and the facilities for dams and races, as well as for

* Quoted from a report on a survey of the Cape Fear and Deep rivers, by Mr. George H. Elliot, annual report chief of engineers, 1872, p. 742. Much of my information regarding the Cape Fear and Deep rivers has been derived from this report.

building, are said to be good. On account of its inaccessibility I did not visit the place, but I have been informed by good authority that the power is available. The greatest drawback would probably be the heavy freshets to which the river is subject, and which have been already referred to; but the fall is so great at this place that it seems as though this difficulty might be, to a large extent, obviated, if it were not endeavored to utilize the total available fall at low water. There is no power at present in use at the place, or if there is, it is only for some small country grist-mill; but none such were heard of.

The drainage area above this place being about 3,400 square miles, I have estimated the power in the following table:

Table of power available at Smiley's falls (estimated).

State of flow (see pages 18 to 21).	Drainage area.	Rainfall.					Flow, per second.	Horse-power available, gross.		Horse-power utilized.	Per cent. of minimum utilized.
		Spring.	Summer.	Autumn.	Winter.	Year.					
	Sq. ms.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*	*1 ft. fall.*	*27 ft. fall.*		
Minimum	3,400	12	13	10	11	46	620	70.0	1,890	0	0
Minimum low season							820	92.7	2,500	0	0
Maximum, with storage							2,400	272.7	7,360	0	0
Low season, dry years							930	106.0	2,860	0	0

To use the power available with storage is probably altogether impracticable, as already remarked in the case of the Roanoke. For the same reason a concentration of power into less than twenty-four hours would probably be impracticable, except to a very small extent.

This power, one of the finest in this section of the state, is located in a region offering many advantages for manufacturing. Fuel, in the shape of timber and coal, is abundant in the immediate neighborhood. Building materials—fine wood and stone—are also to be had with ease. The principal economic drawback is the inaccessibility of the place, the nearest railroad being the Cape Fear and Yadkin Valley railroad, whose nearest point is 20 miles distant. The products of the neighborhood are corn, cotton, wheat, oats, rye, pease, potatoes, vegetables, and fruits of various kinds. In case of the establishment of a cotton factory, an abundance of the raw material could probably be obtained from wagons. Finally, this part of the state is quite healthy, although not so much so as the western portion, chills and fever being more prevalent.

The next dam above Sharpfield dam was McAllister's, 3 miles above, the present fall in the river between these points being about 8 feet. Then came Fox's Island dam, 3 miles above, the natural fall being now 10 feet. The next was Douglas' falls dam, rather over 8 miles above, and the fall is 9 feet. The bed of the river above Smiley's falls is rock, and the fall considerably greater than below. The next dam above Douglas' falls was Battle's, which is the first dam at present existing on the river, having been, as already mentioned, the lowest dam rebuilt by the last company. The fall between this dam and Douglas' falls, a distance of a little over 3 miles, is 9 feet. Battle's dam is a wooden structure, straight across the river, and about 11 feet high and 500 feet long. It is not used for power, although it might be, as the place is topographically favorable, but the freshets would be a drawback to the use of so small a fall. The dam ponds the water for 2 miles, up to the foot of Buckhorn falls, the most important fall on the river next to Smiley's, and navigation through which is effected by means of a canal. At the head of the falls is a dam, built of wood, like Battle's dam, and about 1,000 feet long and 3 or 4 feet high. It has the shape of a letter V, with the apex up stream, one arm being nearly at right angles to the banks, and it is terminated on the east side by an island, behind which it turns a portion of the water, as into a natural race, which extends for a distance of a mile or so between the bank and a succession of islands, which have been connected by a series of slough-dams. At the end of the mile a slough-dam connects the last of the series of islands with the bank, and the navigation is continued by means of a canal about half a mile long, 40 feet wide at the surface, and 6 feet deep. At its head is a guard-lock, with a lift of about 4 feet, and at its foot two locks, made of crib-work filled with stone, like the guard-lock, with together 17 feet lift, one having 11 and the other 6 feet, making the total fall from the crest of the Buckhorn dam to that of Battle's dam some 22 or 23 feet. A part of the fall has been used by the North Carolina Iron and Steel Works to run machinery connected with their furnaces (blast, etc.), the canal having been extended some 300 yards from a point just above the outlet-locks, so as to utilize the power lower down, nearer the ore-bed. A fall of 12 feet was used, the water being discharged into a small creek having a fall of some 5 feet between the tail-race and the river. Although in freshets the backwater from the river came up to the wheel-pit, full capacity could be secured during the whole year, and no steam-power was used. These works have not been in operation since 1876, it being said that the ore-bed is exhausted, not being so extensive as was supposed, although it is not certain that this is the case.

These falls constitute a most excellent power, very easily available, and with a location perfectly safe. The

existing canal constitutes a race ready for use, and by utilizing the lift of the guard-lock and discharging the water directly into the river at the works a fall of 20 feet could be rendered available, except during very severe freshets, when the works might be obliged to stop, although this would be *very* rare. The canal is in tolerably good condition, and could be made perfect at a very small cost; and, if necessary, it could be easily widened so as to increase its capacity. At its lower end, where the locks are, the land is low for several hundred yards back from the river, and subject to overflow at times; but further back is a hill, on which buildings could be erected with safety, and on which stands the furnace of the iron company.

I have estimated the available power and flow at this point, with the results given in the following table:

Table of available power at Buckhorn falls (estimated).

State of flow (see pages 18 to 21).	Drainage area.	Rainfall.					Flow per second.	Horse-power available, gross.		Horse-power utilized.	Per cent. of minimum utilized.
		Spring.	Summer.	Autumn.	Winter.	Year.					
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. feet.*	*1 foot fall.*	*20 feet fall.*		
Minimum	3, 200	12	13	10	11	46	575	65. 4	1, 300	0	0
Minimum low-season							765	87. 0	1, 740	......	......
Maximum, with storage							2, 240	253. 4	5, 000	......	......
Low season, dry years							875	100. 0	2, 000	......	......

To utilize the whole of the minimum power with a fall of one foot per mile to the canal would require a canal with rather larger dimensions than those given for the present one. With a fall of 2 feet per mile, however, the present one would answer, the banks being composed of earth, with no special precaution to keep them smooth. The present canal, or one 40 feet wide at top, 6 feet deep, and slopes of 45°, would be capable of carrying volumes of water, and of affording power, with different slopes, as per the following table:

Table of power afforded by canal in earth, 40 feet wide, 6 feet deep, sides at 45°, at Buckhorn falls.

Fall of canal.	Capacity per second.	Horse-power available, gross.		Remarks.
	Cubic feet.	*1 foot fall.*	*Total.*	
1 foot per mile	450	51	1, 020	Available fall about 20 feet.
2 feet per mile	625	71	1, 349	Available fall about 19 feet.
3 feet per mile	790	90	1, 620	Available fall about 18 feet.

The estimates of flow in the first table, and in that for Smiley's falls, may seem too low, but the flow of the Cape Fear was stated to be very variable. The available power, with storage, would be found impracticable, I think, although the power due to the ordinary flow of the stream might be considerably increased by constructing storage-reservoirs in the valleys of Deep and Haw rivers.

Buckhorn falls are more accessible than Smiley's, being only about 8 miles from Haywood, at the junction of Haw and Deep rivers, and from the Raleigh and Augusta Air-Line railroad, which crosses both rivers near their junction. As already mentioned, coal and building materials can be obtained in abundance in the vicinity. The locality is healthy, and the climate mild. The property, including land, canals, and dams, is all owned by the Navigation Company.

The width of the Cape Fear at Buckhorn dam is about 700 or 800 feet, and the dam ponds the water with this average width up to the forks, and beyond, or about 8 miles. Buckhorn falls is thus the highest power on the river.

In the following table of power on the Cape Fear river I have only mentioned those powers which may be considered as available practically, viz: Smiley's falls, Battle's dam, and Buckhorn falls. As curiosities simply I have added the theoretical power between certain points.

It will be noticed that there is only one mill in operation on the river, probably because small mills—the only kinds that have ever sought a location in this part of the state—have been more cheaply located on small streams, where there is not such danger from heavy freshets.

Cape Fear river—Summary of power (estimated).

Locality.	Distance from Fayetteville.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Total utilized.		Per cent. of minimum utilized.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.†	Low season, dry years.	Fall.	Horse-power, net.	
	Miles.	Sq. ms.	In.	In.	In.	In.	In.	Feet.	Miles.					Feet.		
Smiley's falls	30.5	3,400	12	13	10	11	46	27	3.5	1,890	2,500	7,360	2,860	......	......	......
Battle's dam	48.0	3,200	12	13	10	11	46	11	0.0	720	950	2,780	1,100	......	......	......
Buckhorn falls	51.0	3,200	12	13	10	11	46	‡20	1.5	1,300	1,740	5,000	2,000	....	......	......
Between Fayetteville and foot of Smiley's falls	0.0 27.0	4,250 3,400	12	13	10	11	46	35	27.0	2,800	3,650	10,000	4,200	10	15	1—
Between head of Smiley's falls and Battle's dam	30.5 48.0	3,400 3,200	12	13	10	11	46	26	17.5	1,750	2,275	6,800	2,600	......	......	......
Total between Fayetteville and junction of Haw and Deep rivers	0.0 60.0	4,250 3,025	12	13	10	11	46	127	60.0	9,000	12,000	36,750	13,700	......	......	.....

* See pages 18 to 21. † Not available practically in all probability. ‡ See description.

Table giving number and location of dams constructed on the Cape Fear and Deep rivers by the Navigation Company, together with a profile of the rivers between Fayetteville and Hancock's dam.

[Taken from a map and profile of the rivers according to a survey by Hamilton Fulton, civil engineer, in the office of the state geologist in Raleigh.]

Name of dam or place.	Distance from Fayetteville bridge.	Elevation of crest or water surface above low-water at Fayetteville.
	Miles.	Feet.
Fayetteville bridge	0.00	0.00
Jones' Falls dam	7.73	50.00
Silver Run dam	17.11	20.64
William's fish-trap dam	25.00	25.74
Haw Ridge dam	26.99	34.97
Green Rock dam	28.14	45.47
Big Island dam (Narrow Gap?)	29.37	53.61
Sharpfield dam	30.59	62.56
McAllister's dam	33.65	73.18
Fox's Island dam	36.50	80.46
Douglass' dam	44.76	88.68
Battle's dam	47.97	99.51
Buckhorn falls	50.00	108.47
Buckhorn dam	51.65	122.39
Deep river, near junction with Haw	60.44	127.11
Lockville dam (lower)	....	151.67
Lockville dam (upper)	62.21	165.02
Gorgas dam (Clegg's)	64.70	172.24
Endor dam (Farish's fish-trap)	71.43	174.36
Gulf dam (Haughton's)	81.37	181.66
Carbonton dam (Evans')	87.37	190.12
Tyser's dam (Hancock's)	99.87	204.64

NOTES ON THIS TABLE.—The height of each dam may be found approximately (a little too large) by subtracting from the height of its crest that of the dam below, except in cases where locks and canals were used, *i. e.*, in the case of the Buckhorn dam, the lower Lockville dam, and the Gorgas dam.

These figures, having reference to the work as originally planned, are not correct for those now in existence, for in some cases these figures were altered when the works were built, and in others they have been altered since.

TRIBUTARIES OF THE CAPE FEAR BELOW THE FORKS.

The first important tributary of the Cape Fear, as we ascend the river, is the Northeast Cape Fear, which rises in the extreme northern part of Duplin county and flows south, through Pender and New Hanover counties, entering the Cape Fear river at Wilmington, some 20 miles from the sea. Lying entirely below the fall-line, it has no water-power of any consequence, flowing mostly through swamps. There are only a few small mills on the stream and its tributaries.

The next important tributary is South river, also from the east, rising, under the name of Black river, in the northeastern part of Harnett county, and flowing south through that county, and between Cumberland, Bladen, and

Brunswick counties on its right, and Sampson and Pender on its left, entering the Cape Fear about 10 miles above Wilmington, after a course, in a straight line, of about 85 or 90 miles. Its drainage area comprises about 1,430 square miles. Although its sources are above the fall-line, the stream is very small where it enters the eastern division, and its water-power is, therefore, of no consequence. Some of the small tributaries near its sources have, as in the case of the Northeastern Cape Fear, small grist-mills, but of no consequence. The South river has one large tributary, the Black River (not the one above mentioned), which enters from the east, after having flowed, from north to south, through the whole length of Sampson county, in the northern part of which its sources lie. Its length is about 50 miles in a straight line, and its drainage area 620 square miles; but as it lies entirely in the eastern division, it possesses no water-power. There are no towns of importance on these streams. They are so swampy that the towns are located some miles from them on higher and more healthy ground.

We next come to Rockfish creek, which rises in the western part of Cumberland county, flows nearly east, forming for about 10 miles the boundary between Cumberland and Robeson counties, and empties into the Cape Fear about 10 miles below Fayetteville, in the former county. Its length, in a straight line, is about 30 miles; following the general course of the stream it is about 35 miles, but taking in all its windings it is considerably more. It drains, in all, an area of 280 square miles, and its principal tributaries are from the north, the largest being the Little Rockfish, draining an area of 77 square miles. There are no towns on the stream.

Rockfish creek is a good sample of a class of streams which I have not yet described in detail, not having had occasion to refer to any particular powers on any of them, although some tributaries of the Neuse and Tar belong to this class. These streams, located generally just below the fall-line, which they sometimes cross, differ very materially in character from the majority of streams in this part of the country. I have alluded to the fact that just below the fall-line there is a belt of sand-hills, some 30 or 40 miles wide, running almost parallel with that line, and sometimes extending above it. The streams of the class referred to rise and flow through this sandy region, and it is to this fact that their character is due. The sand-hill belt consists of broad, flattish swells, well wooded, as a rule, with long-leaf pine, and generally with an undergrowth. The surface deposit of sand varies generally from a foot or two to five or six feet in depth, and is in places 10, 20, and even 100 feet thick. It is underlaid with an impervious stratum of half-compacted grit or clay of the tertiary formation (overlaid at points by a stratum of gravel several feet thick), which is in places very thick, having been bored into to a depth of 66 feet at one place. The smaller streams in the sand-hills have not cut out their beds through the sand, and are often sluggish, stagnant, and marshy; but the larger creeks, and the rivers, have cut away the sand entirely and worn out their beds in the impervious stratum beneath, which sheds into the water-courses all the water which reaches it by percolation.

The rapidity with which the sand-hills absorb the rain which falls upon them, thus removing it from the direct action of the sun, has the effect of diminishing the evaporation, while their large thickness in places enables them to absorb considerable water, and to give it out gradually, as it reaches and flows along the impervious stratum beneath, thus enabling them to act as storage-reservoirs, and to regulate the flow to a remarkable degree. Thus there is considerable difference in the sand-hill streams, according to the depth of the sand on their drainage-basins, and by no means are all these streams good sources of power. Sand and gravel in general, although they absorb water rapidly, give it out rapidly also, unless occurring in sufficient masses to be able to store up considerable water without becoming saturated. Hence the depth of the sand-hills acts very beneficially, and when the sand is deep the streams of the class referred to not only discharge a large proportion of the rainfall on their drainage basins, but discharge it very uniformly, their flow being remarkably constant. The power which can be obtained from these small streams is sometimes remarkable, and we shall see further on that it is one of them which is the principal manufacturing stream in the state of South Carolina. Their value is also increased by the fact that the topography of the sand-hill region is such that large ponds can be obtained easily, and storage-room sufficient, not only to regulate the flow to a considerable extent during the year, but also to permit of the concentration of the entire flow of the stream into working hours, thus rendering it possible to double the power due to the natural flow if the mills are only worked 12 hours. Those streams which have cut deep channels for themselves through the sand down to and into the impervious stratum of hard pan flow considerably below the general surface of the country, often 50 or 60 feet. The banks of the Big Rockfish, for example, are almost 100 feet high near the Cape Fear, and well wooded. These sand-hill streams are, of course, not subject to such heavy freshets as ordinary streams. Big Rockfish has been known to rise 14 feet, but 10 feet is a very large rise, while Little Rockfish rises only 6 or 7 feet. There is, however, not much land overflowed. The smaller streams, however, are sometimes bordered by wet grounds, heavily wooded and overgrown, nearer the general surface of the ground, and lying high above the beds of the main streams. Though the sand-hills are, as a rule, well wooded, the woods have in parts been cut down to a considerable extent, and it is stated, and doubtless truly, that the flow of the streams in these sections is more variable than formerly.

Regarding available power on these streams it was difficult to obtain much information, owing to the fact that the streams have a uniform declivity, with no falls, so that power may, as a rule, be obtained at almost any point where the banks are favorable for the location of a dam and buildings.

The drainage-basin of Rockfish creek lies below the fall-line; and the stream has no falls, but a gradual declivity.

The map shows the general form and position of the basin. Like the others of this class, it has no lakes, but the facilities for constructing reservoirs are tolerably good. The banks are moderately high, and seldom overflowed; the rise in freshets is small, the flow very constant and strong, and the fall rapid. The rainfall is about 46 inches, 12 in spring, 13 in summer, 10 in autumn, and 11 in winter—a distribution which, of itself, would tend to render the flow constant. The stream is used for rafting, and there are no mills on it for 15 miles from its mouth, although formerly there were one or two saw-mills below the mouth of Little Rockfish, and above that are a few small country saw- and grist-mills, herein tabulated. Of the available power of this stream a very small proportion is utilized. Some of its tributaries, however, are well utilized. The most important is Little Rockfish creek, which is the same in general character as the main stream, which it enters about 7 miles, in a straight line, from the Cape Fear. The first power on this stream is an unimproved site formerly occupied by Murphy's paper-mill, with 18 feet fall, and an available power, at all seasons, of at least 100 horse-power net (with good wheels), judging by the power used at the other mills on the stream. This power is one-fourth of a mile from the mouth of the stream, with no important tributaries below it. The drainage area above is therefore about 77 square miles.

About 1½ miles above this site is the Hope mill of the Rockfish Manufacturing Company (T. Campbell Oakman, president*), a cotton-mill, with grist- and saw-mill attached, using a power of about 130 horse-power, with a fall of 23½ feet. The dam is of wood, 53 feet long and 20 feet high, rebuilt in 1872 at a cost of about $2,000, and ponding the water over about 200 acres to a depth of 7 feet. A race 300 feet long leads to the wheel. No steam is used for power, and by storing the water during the night full capacity may be obtained at all seasons, the factory being run during 12 hours. Mr. Oakman has carefully measured the water used by his wheels, and states it to be 89.7 cubic feet per second, saving the water at night; *i. e.*, the natural flow of the stream is never less than 44.5 cubic feet per second. The drainage area above the mill being about 70 square miles, the stream discharges at its minimum 0.63 cubic foot per second per square mile—a remarkable discharge.

A mile and a half above Hope mill is the Bluff mill (H. & E. J. Lilly), a cotton factory, with a fall of 9 feet, using 57 horse-power. The dam is earth, 900 feet long, 10 feet high, built in 1872, and costing $5,000, and the pond covers 75 acres to an average depth of 8 feet. Full capacity can be secured the whole year. The drainage area above being about 55 square miles, the discharge of the stream should be very nearly 0.63 cubic foot per second per square mile to give the power stated if the water is stored at night.

The only other power worth mentioning specially is the Beaver Creek mill (H. & E. J. Lilly), just above the Bluff mill, situated on Beaver creek, a tributary of the Little Rockfish—a cotton-mill, using 111 horse-power and a fall of 14 feet. The dam is earth, 1,500 feet long, 14 feet high, built in 1841, and ponding the water over 200 acres to a depth of 12 feet. A race 100 feet long leads to the mill. Full capacity can be secured the entire year. A calculation, on these data, gives the discharge of the stream so great that I am inclined to think that some of the figures must be erroneous. In fact, the amount of machinery run in the mill is not much greater than in the Bluff mill, according to the "Hand-book of the Department of Agriculture".

Above the Bluff mill the Little Rockfish and its tributaries are well utilized by a number of small saw- and grist-mills.

Above the Rockfish there are a number of smaller streams belonging to the same class which flow into the Cape Fear, two of which empty almost in the town of Fayetteville, and on which there were four factories before the war, but the powers are small—not over 20 or 30 horse-power probably. There are some small grist-mills on all these streams, generally running two pair of stones. About 7 miles above Fayetteville there is a small tributary (Carver's creek) which, near its mouth, falls over a ledge of hard pan and soft rock a distance of 18 or 20 feet, but in dry weather there is hardly any water in the stream. The next important stream above Rockfish is Lower Little river, which rises in Moore county and flows east through Cumberland, and between Cumberland and Harnett, emptying into the Cape Fear below Averysboro'. Its length is 45 miles in a straight line, and its drainage area about 448 square miles. The principal town on the stream is Manchester, a very small place. This stream, with its tributaries, may be classed among the sand-hill streams, but its basin lies near the upper limit of the sand-hill belt, and so the general character of the sand-hill streams (like the Rockfish) is not so pronounced here, the flow being not quite so constant and the freshets rather more violent, the water rising some 15 feet. The banks are high and well wooded, and the bed of the stream the same as has been described; the country, as a whole, is not so sandy. The fall of the stream is uniform, and at the rate of 3½ feet per mile.† I have estimated the flow as follows:

Place.	Drainage area.	Flow per second.		Horse-power, gross.		Utilized.		Gross horse-power available, with fall used.
		Minimum.	Ordinary summer.	Minimum.	Ordinary summer.	Horse-power, net.	Fall.	
	Square miles.	*Cubic feet.*	*Cubic feet.*	*Per foot fall.*	*Per foot fall.*		*Feet.*	
At mouth	448	224	336	25.4	38.2	100+	12.0	304
At Manchester	329	164	246	18.6	28.0	20	3.5	65

* I am indebted to Mr. Oakman for most of my information regarding the streams in this vicinity.

† The elevation above tide at crossing of Raleigh and Augusta Air-Line railroad is about 221 feet, and at mouth say 31 feet. Length, measured from map, is about 55 miles.

In the foregoing estimate 0.5 cubic foot per second per square mile was assumed as the minimum flow, and 0.75 cubic foot per second per square mile as the ordinary low-water flow. These figures are very high—perhaps too high—but a series of gaugings only can serve as a correct guide.

The power of the stream is utilized by one cotton factory and a number of saw- and grist-mills. The first mill is 2½ miles from the mouth, with a fall of 12 feet, not subject to interruption, except sometimes for a day or two by backwater from the Cape Fear. At Manchester is the cotton- and woolen-mill of the Linwood Manufacturing Company, using a fall of 3½ feet and about 20 horse-power. The Manchester mill, a cotton factory of about the same size, uses power from a small tributary. There are doubtless many places on Lower Little river where dams might be located and excellent power obtained.

Upper Little river is a stream similar to Lower Little river, except that it is still less of a sand-hill stream, and said to be not so bold or so reliable as the latter. It is only used for saw- and grist-mills, and there are, no doubt, sites not used. Each of these streams is about 100 feet wide at its mouth. The length of Upper Little river is about 32 miles, measured in a straight line, its drainage area 176 square miles, and its fall, from the crossing of the Raleigh and Augusta Air-Line railroad to its mouth, about 290 feet, or perhaps at the rate of 6 feet or over to the mile.

Above Upper Little river there are no tributaries to the Cape Fear which are worth mentioning specially, although there are some small creeks which afford good small powers, and are utilized for grist- and saw-mills.

HAW RIVER.

This river rises in Rockingham and Guilford counties, North Carolina, pursues a general southeasterly course through Alamance, a corner of Orange, and Chatham counties, and in the southeastern corner of the latter unites with the Deep river to form the Cape Fear, which has just been discussed. The length of the stream, following its general course, is about 80 miles, but considerably more if all its windings are followed. Near the northwest corner of Alamance county the river forks, the north fork going by the name of Haw river, while the south fork is known as the Reedy fork of Haw river. The Reedy fork, as well as the north fork in its upper parts, flows nearly east, but the course of the stream below the junction of the two is nearly southeast. There are no large towns on the river, but Graham, the county-seat of Alamance county, is only a mile or so distant.

The drainage area of the Haw river comprises about 1,675 square miles, and the stream receives two important tributaries: the New Hope creek, from the east, draining about 317 square miles, entering about 3 miles above the junction of Haw and Deep rivers, and Alamance creek, from the west, draining about 237 square miles, and enters the Haw river about 4 miles south of Graham. The Reedy fork receives as its principal tributary Buffalo creek, from the south, draining about 128 square miles, and the north fork receives Troublesome creek, from the north, with a drainage area of about 88 square miles. The map shows the position of all these streams.

Haw river flows through a fertile country lying in the center of the cotton-belt, and the productions of which are about the same as along the upper part of the Cape Fear, viz: corn, cotton, wheat, oats, rye, tobacco, grasses, a great variety of vegetables, and fruits. It is tolerably well wooded, although not enough care is taken to preserve the forests. Topographically, the region, especially in the lower part, is more broken than the drainage-basins of the Neuse, the Tar, or the Roanoke rivers. The mineral resources of the basin are very great, iron being found in various places in large quantities, and of very fine quality. Copper has also been found, but the mines have been little worked. Building-stone of good quality is found all through the basin. In fact, in regard to building-stone in the middle and western divisions of the southern Atlantic water-shed, as Professor Kerr has remarked, "it would be tedious to particularize, as granite and gneiss are everywhere."

The bed of the stream is generally rock, covered in places with deposits of sand, gravel, or clay, but affording almost everywhere excellent foundations for dams. The banks on the lower part of the stream are tolerably high, in some places very steep, and the bottoms are narrow and not much subject to overflow, while in the upper part of the stream, where the country is not so broken, the banks are, in places, low. In the upper parts of Alamance and Guilford counties the country is much flatter than in Chatham county. The stream is subject to very heavy freshets, and there are no lakes serving to restrain their violence; but the stream is rarely frozen over, and the mills suffer no trouble with ice. Some of the tributaries of the stream rise in a region where the prevailing rock is a slate, which is covered with a thin soil and sometimes with none at all; and from this region the rain-water is shed very rapidly, so that these streams are nearly dry in summer. But Haw river is less affected in this way than Deep river, because only a few of its tributaries rise in this region, in consequence of which the latter stream is said to be more variable in flow and more subject to freshets than the former. The facilities for the construction of storage-reservoirs are said to be good in the upper part of the stream, though I do not know that any surveys or examinations have ever been made with a view to determining this point accurately.

The rainfall in the valley of the Haw river is about 45 inches, distributed as follows: spring, 12; summer, 12; autumn, 11; winter, 10; its distribution throughout the year being quite uniform, judging from the chart published by the Smithsonian Institution.

The fall of the stream between different points will be seen from the following table, which gives the elevation at several points; and it will be remarked that the fall of the stream is quite large for one not rising in the mountains, being much larger than that of any stream, or of any part of a stream, which we have yet considered, which lies in the middle division:

Table of declivity—Haw River.

Place.	Distance from mouth.*	Elevation above tide.	Distance between points.	Fall between points.*	Fall between points per mile.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
At confluence with Deep river	0	130	50	320	6.4
At crossing of North Carolina railroad†	50	450	30	226	7.5
Reedy fork, at crossing of Piedmont Air-Line	80	676	27	197	7.3
Haw river (North Fork), at crossing of Piedmont Air-Line	77	647			

*Distances based on measurements from a map, made to follow the windings as closely as was practicable.
†Based on a rough estimate of the height of the railroad bridge above water.

The flow of the stream in different seasons is not known with accuracy. Professor Kerr states the flow at its mouth to be 1,760 cubic feet per second, but as this is not low-water, and probably more nearly the average flow, it is of no value for our computations.* I am therefore forced to base my figures, as usual, on estimates from drainage area and rainfall.

Haw river (crossed almost at right angles by three railroads) is not very accessible. Especially is this the case with that part of the river below the crossing of the North Carolina railroad at Haw river, in Alamance county, while above that point the stream is, on the average, about 8 miles from the railroad, to which the Reedy fork runs nearly parallel. A railroad has been projected to run from the junction of Haw and Deep rivers up the valley of the Haw, starting from Moncure, following the river to a point about 6 miles above the crossing of the North Carolina railroad, and then passing, via Yanceyville, Caswell county, to Danville, Virginia. The charter has been obtained, but no surveys have yet been made; and although subscription-books have been opened, there has not yet been a meeting to organize.

The foregoing general sketch shows that the Haw river ought to afford a great deal of water-power on account of its rapid fall and the fact that it crosses the ledges of rock at large angles, and the following account of the power on the stream will show that this is the case, and that the Haw river is well fitted, in some respects, to become a large manufacturing stream, and indeed it is at the present time one of the principal manufacturing streams of the state.

Commencing at the mouth of the river, the water-powers met with, in ascending the stream, will now be described.

The first power is situated 3 miles from the junction, and just below the mouth of New Hope river. It is utilized by a mill belonging to the American Iron and Steel Company, and known as the "Bland mill". The banks on the east are favorable for building, and not often subject to overflow, while on the west rises a rocky bluff to a height of over a hundred feet. Diagonally across and up the river from the east bank to this rocky bluff extends the dam, a wooden structure, 300 feet long, 7 feet high, vertical in front, but sloping downward on the up-stream side, and throwing the water back for over a mile, with an average width of 200 feet, the river not being thrown out of its banks. At the east end of the dam is the mill, a grist-mill, running two pair of stones, with 7 feet fall, and using perhaps 20 horse-power net. This mill can run during eleven months of the year, but during the remaining month is troubled with backwater on account of the small fall. There is at all times, of course, a great excess of water. In the summer of 1880 about 80 feet of the dam at the western extremity was undermined and carried away by a freshet, but has since been rebuilt. The dam as it stands would probably cost some $2,000. The river here is about 250 feet wide, and the water rises very high in freshets, sometimes 30 or 40 feet, but there is no trouble with ice. The drainage area above this power being about 1,675 square miles, I have estimated the power as in the following table:

Table of power at the Bland mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*
Minimum	1,675	7	280	32.3	225
Minimum low season			335	38.0	270
Maximum, with storage			1,340	152.0	1,050
Low season, dry years			380	43.5	300

*Professor Kerr's statement is that the river affords 200 horse-power per foot of fall at its mouth. (Geol. Rep., p. 39.)

The effect of the uniform distribution of the rainfall is to render the flow more variable and to decrease the minimum flow, while at the same time the total amount of power or flow available, with storage, is increased beyond what it would be were the summer-fall greater. It was stated to me as a fact that the flow of this stream is very variable. The maximum flow given as available, with storage, would require the construction of storage-reservoirs with a capacity in all of at least 900,000,000 cubic feet, which would require, for instance, if only one reservoir were used, one of say 2 miles square and between 8 and 9 feet deep. Such a large amount of storage would, of course, be very expensive. The pond at the Bland mill is, of course, not large enough to furnish any appreciable storage, or to allow of the concentration of the available power into working hours. The site is not an especially good one for large establishments on account of the small fall and the trouble resulting from backwater. It is, however, very favorably located within a few miles of the Raleigh and Augusta Air-Line railroad, and in a healthy part of the state.

The next power above this is situated about 2 miles further up the stream, and is not improved. It is known as Hartsaw's site, and it is said that the available fall amounts to 6 feet. Being above the mouth of the New Hope, the drainage area amounts to about 1,320 square miles, and the power available will be about 0.67 of that at the Bland mill, or as follows:

Power at Hartsaw's site.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*6 feet fall.*
Minimum	1,320	6	218	24.7	150
Minimum low season			264	30.0	180
Maximum, with storage			1,060	120.0	720
Low season, dry years			300	34.0	200

The next power is Moore's mill, improved and in use, situated some 3 miles above Hartsaw's. There is no dam, but a race some 200 yards long leads to the mill—a grist-mill, with 2 or 3 run of stones, together with a saw-mill, cotton-gin, and foundry, using a fall of some 10 feet (?) and a small amount of power. The shoal is about a mile long, and the total fall is said by good judges to be about 22 feet; but I did not examine the place, and am not able to vouch for this statement. In dry weather a rough dam of stone turns the water into the race, but this is disturbed in freshets, and in ordinary times is not necessary. The power used I am unable to state exactly; that available, assuming the fall to be 22 feet, is estimated in the following table:

Power at Moore's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall assumed.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*22 feet fall.*
Minimum	1,300	22	214	24.0	525
Minimum low season			260	30.0	660
Maximum, with storage			1,040	118.0	2,600
Low season, dry years			295	33.7	740

This site, one of the best on Haw river, is quite easily accessible, being only about six miles from the Raleigh and Augusta Air-Line railroad, and about the same distance from Pittsboro', the county-seat of Chatham county. It is well worthy of the attention of capitalists desiring to locate in this vicinity.

The next power above Moore's is about 2 miles above, an unimproved site, with a fall said to amount to 8 feet. The power here will be a very little over one-third of that at Moore's, and is given in the table beyond, with a summary of all the others.

Next comes a second unimproved site, known as the Seven Island shoal, where the fall is said to be 7 feet. It is 2 miles above the one last mentioned, and the power is tabulated beyond.

Next comes the mill and site of Stephen Henley,* about 1½ miles above Seven Islands, and just about on the road from Pittsboro' to Raleigh, and 12 or 13 miles from the mouth of the stream. A wing-dam 500 feet long and 3½ feet high extends across to an island and serves to turn the water into the race, which carries it about 100 yards, affording a fall at the mill of 8 feet. The dam was built in 1874 and 1875 at a cost of some $500, and is of rock, planked over, and backs the water some 600 feet. The mill is a grist-mill, and uses about 50 horse-power. It is situated on the west bank, but the principal channel of the river is on the east side of the island above referred to,

* To Mr. Henley I am indebted for the greater part of my information regarding this part of the Haw river. Mr. Henley is thoroughly acquainted with the water-power in this vicinity.

which is about half a mile long. Mr. Henley estimates the fall at this place at about 16 feet. Taking this estimate as correct (though I cannot vouch for it), the available power at this place may be estimated as follows:

Table of power at Henley's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall assumed.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	16 *feet fall.*
Minimum	1,285	16	200	22.7	360
Minimum low season			260	30.0	480
Maximum, with storage			1,040	118.0	1,888
Low season, dry years			295	33.7	540

The next power is Brown's mill, where there is said to be about 7 or 8 feet. I have no further particulars regarding this place. It is about 1½ miles above Henley's, and the power is tabulated beyond. The power is said to be not in use at present.

The next is an unimproved fall of some 8 feet, belonging to the Bynum Manufacturing Company, formerly used, but now altogether abandoned. The estimated power is given in the table.

We next come to the cotton-mill of the Bynum Manufacturing Company, about 4 miles above Henley's mill. The dam is of wood, built in 1860 at a cost of $500, and is 475 feet long and 3 feet high, ponding the water over 10 (?) acres. A race 600 yards long leads to the mill, where the fall is 16 feet, and 80 horse-power is used. The mill is run night and day, and water always wastes. The following table gives my estimate of flow and power:

Table of power at mill of Bynum Manufacturing Company.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	16 *feet fall.*
Minimum	1,250	16	200	23.4	375
Minimum low season			250	28.4	450
Maximum, with storage			1,000	113.6	1,825
Low season, dry years			280	32.4	510

One mile or less above Bynum's is R. J. Powell's mill-site, the mill having been recently burnt. The dam is of wood and stone, and extends entirely across the river, and a fall of about 7 feet was used.

Less than a mile above Powell's is Burnett's unimproved site, where the available fall is said to be about 6 feet.

A short distance above this is Pace's mill. The dam is 300 feet long, from which a race 450 feet long leads to the mill, where a fall of 12 feet is used. Mr. Pace has a flour- and corn-mill, with four pair of stones, a saw-mill, wagon-shop, and blacksmith-shop. He writes that upon his property, which extends for three-quarters of a mile along the river, there are two sites not used—one below the mill, with 10 feet fall, and another above, with 13 feet fall—available, with a dam 4 feet high, 600 feet long, and a race 600 feet long.

Table of power at Pace's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	12 *feet fall.*
Minimum	1,209	12	192	21.8	260
Minimum low season			237	27.0	325
Maximum, with storage			980	111.3	1,335
Low season, dry years			273	31.0	370

The next mill above Pace's is Love's, about three miles above, but between the two it is said that there are several sites not used. The river is said to be quite rapid at this point of its course. At Love's mill there is a dam across the river 700 feet long, and the fall at the mill is said to be 11 feet, the mill being a grist- and saw-mill.

Table of power at Love's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	11 feet fall.
Minimum	1,155	11	184	20.9	230
Minimum low season			230	26.1	280
Maximum, with storage			975	110.8	1,220
Low season, dry years			260	29.5	320

Above Love's mill we come to several unimproved sites, among which mention was made of Jeanes' and Stephen Robinson's, but the first improved power above is some ten miles farther up, in Alamance county, near the Orange line. Before leaving Chatham county it may be said that, according to the foregoing, it is clear that Haw river offers a very large amount of power in its course through the county, very little of which is utilized, but a large proportion of which is available. The bed and banks are almost everywhere good, the country hilly, but not mountainous, and the climate healthy. A disadvantage in the use of the small falls which have been mentioned lies in the sudden and large rise to which the river is subject on account of the narrowness of the bottoms. Although in some places the fall is considerable in a short distance, yet on the whole the declivity of the stream seems to be tolerably uniform, while the width of the stream seems to be on an average some 400 feet or more. I desire to expressly state here, however, that none of the data given regarding Haw river, except the facts regarding the Bland mill, were derived from personal examination, for, on account of their inaccessibility, I did not visit any sites except the one mentioned.

The next power above Love's mill is Saxapahaw factory, near Saxapahaw. The dam extends entirely across the stream, and is about 375 feet long and 3 feet high, built of wood in 1878 and 1879, and backing the water about a mile, with an average width of 350 feet. A race half a mile long leads to the factory, where 45 horse-power is used, with 19 feet fall. The mill is a cotton-mill, run night and day. Estimates of the power will be found in sufficient detail in the table giving the summary. This mill being above the mouth of the Big Cane and several other creeks, the stream is considerably smaller than at Love's.

The next power above Saxapahaw is Newlin's grist-mill. The dam is of wood and stone, 600 feet long and 6 feet high, built in 1875 at a cost of $3,500; and from it leads a race, 485 yards long and 10 feet wide, conducting the water to the mill, where the fall is 10 feet, the power used being probably some 40 horse-power net, with three turbine-wheels. The pond covers some 30 or 40 acres, with an average depth of 6 feet or over, but the stream is not thrown out of its banks. This power is located near the town of Cedar Cliffs, Alamance county, and this property, with 350 acres of land, is for sale. I have estimated the power in the table on page 68.

The next power is an unimproved site belonging to the Falls of Neuse Manufacturing Company, where there is said to be 10 feet fall. A grist-mill was formerly located here.

The next mill is the cotton factory of the Falls of Neuse Manufacturing Company, at Swepsonville, Alamance county. The dam is of wood, 550 feet long, 5½ feet high, built in 1876 at a cost of about $3,000, and from it a race 450 feet long leads to the mill, where the fall is 13 feet, and the power used 150 horse-power. Full capacity can be obtained all the time. The factory is run night and day. Connected with it is a grist- and a saw-mill. The factory was burned in June, 1881, but is being rebuilt.

We next come to the Granite cotton-mills of T. M. Holt, at Haw river, just above the crossing of the North Carolina railroad. The dam was built in 1857, and is constructed of crib-work filled with rock. Its length is 350 feet, and its height about 10 feet; and it backs the water some 2 miles, but does not throw the river out of its banks to any extent. The factory is located directly at the dam, on the east side of river, and the power used is 100 horse-power, with a fall of 11½ feet, there never being any scarcity of water. My estimate of the power is given in the summary.

At the head of Mr. Holt's pond is Seller's mill, a site not now used, and owned by the Falls of Neuse Manufacturing Company; said to have about 12 feet fall.

At Big Falls, 3 miles from Graham station, on the North Carolina railroad, Mr. G. W. Swepson, of Raleigh, is building a cotton factory, to use 13 feet fall, and expecting to get 150 horse-power all the time. If my estimates given in the summary are correct, this will be obtained only part of the time unless the pond is large. There was formerly a cotton-mill at this place, but it was burned down.

About half a mile above Big Falls are the Carolina cotton-mills (J. H. & W. E. Holt & Co.). The dam was built in 1868, and is a frame dam, with stone abutments, about 240 feet long and 4 feet high, making a pond of 3 acres, and giving a fall of 15 feet at the mills, three-fourths of a mile below. A power is used of 110 horse-power, which can be obtained all the time, and without drawing down the water in the pond much in the 12 hours during which the mill is run.

Half a mile above a cotton factory, to be called Glencoe mills, is being built by J. H. Holt & Bro., on a site formerly occupied by the Company mills (cotton). The dam, constructed of stone and logs, was built long ago, and

is about 250 feet long and 8 feet high, giving a fall of 13½ feet, with a race 400 yards long. It is expected to obtain 152 horse-power at all times, but according to my estimates I doubt if this can be done unless the pond is large.

Two and a half miles north of the company's shops, on the North Carolina railroad, is an old grist-mill (Ireland's), not now used, although the fall is said to be 10 or 12 feet.

The highest power on the river is about 5 miles from Gibsonville station, on the North Carolina railroad, Although there was a mill there long ago, the power has for some time been lying idle, but has been recently improved by Messrs. Gant & Davidson, who have a cotton factory, flour- and saw-mill there, using a fall of 15 feet, with 150 horse-power, which can be obtained for eight months of the year, and averaging 75 horse-power during the remaining four. The dam is 250 yards above the mill, and is about 200 feet long and 4½ feet high, backing the water only a few hundred yards. It was built about forty years ago, and is constructed of rock. It is stated that the fall at this place could be increased to some 20 feet.

From the above sketch it will be seen that the water-power on Haw river is quite extensively used, especially on the upper parts, where the stream is more accessible. Haw and Deep rivers are, in fact, the principal manufacturing streams of North Carolina, together with the south fork of the Catawba, yet to be described.

Summary of power of Haw river.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*						*Feet.*		
Bland mill	3.0	1,675	12	12	11	10	45	7.0	....	225	270	1,050	300	20	7.0	13	Mill at dam.
Hartsaw's site	5.0	1,320	12	12	11	10	45	6.0	....	150	180	720	200	......	......	......	Not improved.
Moore's mill	8.0	1,300±	12	12	11	10	45	22.0	5,280	525	660	2,600	750	<50	10.0	<14	
Unimproved site	10.0	1,295±	12	12	11	10	45	8.0	....	190	240	940	270	......	......	......	
Seven Island shoal	12.0	1,290±	12	12	11	10	45	7.0	....	170	210	825	240	......	......	......	Unimproved.
Henley's mill	13.5	1,285	12	12	11	10	45	16.0	....	360	480	1,888	540	50	8.0	19	
Brown's mill	15.0	1,275±	12	12	11	10	45	7.0	....	165	200	800	230	?	?	?	Said to be not in use.
Bynum's site	16.5	1,260±	12	12	11	10	45	8.0	....	190	230	900	260	......	......	......	
Bynum's factory	17.5	1,250	12	12	11	10	45	16.0	....	375	450	1,825	510	80	16.0	29	
Powell's site	18.0±	1,240±	12	12	11	10	45	7.0	....	155	190	780	220	......	......	......	Mill burnt; dam still there.
Burnett's site	18.5±	1,230±	12	12	11	10	45	6.0	....	130	165	670	190	......	......	......	Not improved.
Pace's mill	20.0±	1,209	12	12	11	10	45	12.0	....	260	325	1,335	370	75±	12.0	39±	
Several unimproved sites	....	....	12	12	11	10	45	......	....	......	......	......	......	......	......	......	
Love's mill	22.0±	1,155+	12	12	11	10	45	11.0	....	230	280	1,220	320	?	?	?	Probably not over 50 horse-power used.
Saxapahaw factory	38.0±	967	12	12	11	10	45	19.0	....	310	400	1,800	460	45	19.0	19	
Newlin's mill	41.0±	935±	12	12	11	10	45	10.0	....	160	200	940	230	40	10.0	34	
Unimproved site of Falls of Neuse Manufacturing Co.	....	....	12	12	11	10	45	10.0	....	......	......	......	......	......	......	......	
Factory of Falls of Neuse Manufacturing Company.	45.0±	670±	12	12	11	10	45	13.0	....	140	190	870	220	150	13.0	136	? See description.
Granite cotton-mills	50.0±	585	12	12	11	10	45	11.5	....	110	150	670	170	100	11.5	117	? See description.
Seller's mill	52.0±	....	12	12	11	10	45	12.0	....	......	......	......	......	......	......	......	
Big Falls factory	55.0±	494	12	12	11	10	45	13.0	....	95	130	640	150	......	......	......	Being built; expect 150 horse-power.
Carolina mills	55.0±	490±	12	12	11	10	45	15.0	....	110	150	740	175	110	15.0	125	
Glencoe mills	56.0±	475±	12	12	11	10	45	13.5	....	100	140	640	160	......	......	......	Being built; expect 152 horse-power.
Ireland site	....	460±	12	12	11	10	45	10.0	....	60	90	460	110	......	......	......	
Gant & Davidson's mills	....	450(?)	12	12	11	10	45	15.0	....	95	130	675	150	150	15.0	210	

* For explanation of powers estimated see introduction, pages 18 to 21. Power much larger than in last column during nine months of the year.

THE TRIBUTARIES OF HAW RIVER.

The first considerable tributary met with in ascending the river is New Hope river, which enters from the west, after flowing through Orange and Chatham counties, and draining an area of some 317 square miles. The substance of what I could learn regarding this stream is that it is generally sluggish, flowing through a level country, and without water-power of any importance, the only mills being a few small local grist-mills. The power used is tabulated farther on.

The succeeding tributaries of the Haw river are small and unimportant until we reach Cane creek, which enters from the west, at the extreme southwest corner of Orange county. It rises in the extreme west of Alamance

county, with some tributaries from Chatham, and flows very nearly due east and only a mile or so from the county-line, but without leaving Alamance. It has more fall than the streams entering Haw river from the east, but is specially mentioned chiefly on account of its having one factory, the Clover Orchard cotton factory, which is situated some 6 miles from its mouth. The length of the stream, in a straight line, is about 17 miles, and its drainage area 73 square miles. The factory above referred to, with which is connected a grist-mill, uses a fall of 23 feet and 50 horse-power, which can be obtained during nine months of the year, the average during the remaining three months being 25 horse-power, during which period auxiliary steam-power is used. The mill being run only during 12 hours, and there being no waste at night in dry seasons, the natural flow of the stream would afford only, say, 10 horse-power in low seasons, and probably much less when at its lowest. The dam is of rock, 120 feet long and 17 feet high, and backs the water about a mile; the factory is 300 yards below.

The next important tributary is Alamance creek, which rises in the eastern part of Guilford county, pursues a general direction nearly due east, emptying into Haw river about 4 miles below the railroad crossing. Its length is in the neighborhood of 25 miles, and its drainage area about 237 square miles. It receives as tributaries two creeks called Little Alamance, from the north, and Stinking Quarter creek, from the south. There are only two powers on the stream worth mentioning, viz: Alamance cotton factory (E. M. Holt's Sons) and Bellemont cotton-mills (L. B. & L. Holt). The Alamance factory uses a fall of 12½ feet and 50 horse-power, which can be obtained during nine months of the year, while the latter uses a fall of 12 feet and 175 horse-power, which can be obtained for six or seven months, the power sinking in low seasons to 20 horse-power, and steam-power to the extent of 80 horse-power being used during dry weather.

The Reedy fork of Haw river, and the other tributaries and forks in the upper part of the drainage-basin, offer some power, utilized to some extent by saw- and grist-mills, but have no power worthy of special mention. The country is quite flat in the upper part of the basin, and there are no falls in the streams.

THE DEEP RIVER.

This stream rises in the western part of Guilford county, North Carolina, near the sources of the Haw river, flows in a southeasterly direction through Randolph county and into Moore, where it bends quite abruptly, and flows a little north of east into Chatham county, where it joins the Haw to form the Cape Fear. Its length is about the same as that of the Haw river, and its drainage area is 1,350 square miles. It has only one important tributary, Rocky river, from the north, which enters Deep river about 4 miles above Lockville, and drains an area of 205 square miles, all in Chatham county. The most important towns on Deep river are Lockville, near the mouth, Franklinsville, Cedar Falls, and Randleman's Mills, in Randolph county.

The drainage-basin of Deep river resembles that of Haw river so closely that it is not necessary to describe it in detail. In its lower part the river flows, with a tortuous course, through a narrow valley with abrupt banks, and, in a few cases, perpendicular and overhanging cliffs some 100 feet high.

The rainfall on the basin is a little greater than on that of Haw river, with rather more rain in winter, as will be seen from the maps in the Smithsonian publications. The flow of the river is rather more variable, owing probably to the fact that a greater number of its tributaries rise in the slate country and become nearly dry in summer. For the same reason, the freshets are, on the whole, more violent, and the river rises oftener above its banks, overflowing the bottoms on the lower part to a depth of 10 or 12 feet. On the upper part of the river there are probably sites for reservoirs, although Guilford and the neighboring counties are, on the whole, not very favorable for their construction, being too flat.

The following are some elevations on the stream, with distances measured from the map, and resulting declivities:

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Difference of elevation.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth, or confluence with Haw	0	133			
			14	80	5.7
Near Egypt mine*	14	213			
			74	412	5.6
Northern part of Randolph county	88	625			
			12	137	11.4
Crossing of Piedmont Air-Line railroad†	100	762±			

* I think there is some error in this elevation, or in that at the mouth, and that the fall between the two is not so great.

† For this elevation I am again indebted to Mr. T. M. R. Talcott, general manager of the road, who took particular pains to obtain it.

From this it appears that the fall of the stream is not much different from that of Haw river, though greater in its upper part.

There are no records of continuous gaugings of the river.

As will be seen from the map, the river is very inaccessible, there being no railroad within easy reach except at the extreme lower and upper parts. Nevertheless, a number of manufacturing establishments have been located at various points, especially in Randolph county, shipping their products by the Piedmont Air-Line railroad.

The following are the mills and sites, so far as I have been able to learn them:

The first power on the river is at Lockville, about 2 miles from the mouth of the river. The falls, known as Pullin's falls, were overcome by the Navigation Company, and navigation established around them by means of 2 dams and a canal leading down the river from the lower one, with an outlet-lock into the river at the lower end of the town, with a single lift of 24 feet. The lower dam is 600 or 700 feet long, 11 feet high, built of crib-work filled with stone, with a vertical back, and a face sloping down to about 1 foot above low water, the base being 30 feet wide, up and down stream. It is said to have cost about $14,000. It does not extend straight across the river, but has the shape of a letter V, with the apex up stream, and backs the water half a mile, with an average width of about 700 feet, to the upper Lockville dam. The foundation is rock, and the dam is not, to any great extent, liable to injury by freshets. The canal which leads from the dam is less than half a mile long, with a guard-lock at its head having a lift of a foot or so, and the high lock at its outlet below. All along this canal are magnificent sites for mills, which could use a fall varying between 11 and 24 feet, with perfectly safe locations. The following are the mills now in use, all owned by the Navigation Company, viz: 1 cotton-gin, 14 feet fall; 1 saw-mill, 16 feet; 1 grist-mill, 16 feet; 1 foundry, 18 feet; 1 grist-mill, 18 feet; 1 machine-shop, 18 feet; all on the canal, fed directly from it, and discharging the water into the river. The aggregate power used by these mills is not exactly known, but is, perhaps, in the neighborhood of 150 horse-power. There is always a waste of water, and there are about 15 days in the year when there is trouble with backwater, the river at the outlet-lock being probably less than 300 feet wide. In high freshets the water rises 5 feet on the dam. The canal is 40 feet wide, and originally 6 feet deep. With a fall of a foot to the mile it could probably carry the entire flow of the stream at low water; so that the entire power at this place is really at present available, except that the wood-work of all the dams of the company is in bad condition, badly rotten, and there is considerable leakage.

The drainage area above this place being about 1,350 square miles, I have estimated the flow and power as in the following table:

Table of power available at Lockville.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Percentum of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*24 feet fall.*		*Feet.*	
Minimum	1, 350	24	216	24. 5	590	150 ±	14–18	25
Minimum low season			256	29. 1	700			
Maximum, with storage			1, 080	122. 7	2, 950			
Low seasons, dry years			293	33. 3	800			

I think that in low water the reservoir-room would be sufficient to allow of the concentration of power into 12 hours to such an extent as to increase the minimum power by 50 per cent. at least.

This power is an excellent one in all respects. A branch of the Raleigh and Augusta Air-Line railroad leads directly to the mills. There is an abundance of fine building-stone in the neighborhood. There is no trouble with ice, and little with high water. The river is navigable up to Carbonton, so that the copper deposits near Egypt, the coal-beds, and the iron-ores of the valley are easy of access. The location is healthy, and indeed there seems to be no reason why a large amount of power should not be utilized at this place.

The second Lockville dam, half a mile above the first one, is of similar construction, and extends straight across the river, its length being about 700 feet, its height 16 feet, and its pond 2 miles in length, up to the Gorgas canal, with an average width of about 600 feet. It would probably cost some $12,000 to build it now. It is in bad condition, the timbers rotted and the stones gone, but could easily be put in order. The lock at its north end is 115 feet long, 18 feet wide, with a lift of 16 feet. The banks between this dam and the one below are steep and rocky on the north side and shelving on the south. The available power here could best be used on the south side, unless it were desired to use it at Lockville, in which case a canal or flume should be built on the north side. A canal 20 feet wide and 6 feet deep would probably suffice to carry the minimum flow, with a fall of 1½ feet per mile. During the war there was a grist-mill on the right bank, but the dam was not sufficiently secured, and it was washed around at this end. It was rebuilt in 1874, when the last company put the works in order, and 150 or 200 feet of the south part were put in, at a cost of $10,000, several accidents happening during the work. The power at this dam is easily available, although there have been no steps taken to utilize it. The amount of water is the same as at the lower dam, and the available power less in proportion to the fall, *i. e.*, two-thirds of that in the last table. In this case, too, the reservoir-room would, I think, be ample to allow of the concentration of power and to render double the low-season flow available during 12 hours.

Two and a half miles above the second Lockville dam is the Gorgas dam, just below the mouth of Rocky river, extending straight across the river, about 600 feet long and 7 feet high, built of cribs filled with stone, vertical on

both sides, and with a width of 6 or 8 feet, and backing the water up to the Endor dam, a distance of about 7 miles or a little less, with an average width of about 500 feet. This dam is at the head of a canal half a mile long, the third of the navigation canals, with guard- and outlet-locks, at the latter of which is a grist-mill taking water from the canal, using 7 to 8 feet fall and perhaps 20 or 25 horse-power, with 2 run of stones. Full capacity can be secured all the time, except for about 15 days in the year, when the river is high. The location is a very favorable one for building, and all the available power could easily be utilized along the canal, which is of ample capacity to carry the dry-weather flow. The drainage area above this place is about 1,300 square miles, and the amount of water and power less than at Lockville. I have estimated it as in the following table. The pond being 7 miles long, there is no doubt that the low-season flow could be concentrated into 12 hours, so that the power given in the table would be doubled with a small diminution of head. Although this place is not quite so conveniently located as Lockville, it is easy of access from that place, as well as from Eygpt, on the Cape Fear and Yadkin Valley railroad:

Table of power at Gorgas dam.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Per cent. of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*7 feet fall.*		*Feet.*	
Minimum	1,300	7	208	23.6	165	20	7	18
Minimum low season			247	28.1	200			
Maximum, with storage			1,040	118.2	830			
Low season, dry years			282	32.1	225			

The Endor dam is about 400 feet long and 4 feet high, crossing the river in the shape of a V, with a vertical face and inclined back half way across, and an inclined face and vertical back for the remaining distance. It is built of wood, and ponds the water back to the Gulf dam, a distance of 10 miles. As far as the location goes, it could be used for power, but the fall is so small that it would not be advisable. It is not necessary to consider it further. The estimated power is as follows:

Table of power at Endor dam.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Per cent. of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*4 feet fall.*		*Feet.*	
Minimum	1,075	4	160	18.3	70	0	0	0
Minimum low season			200	22.6	90			
Maximum, with storage			900	102.0	400			
Low season, dry years			225	25.6	100			

The Gulf dam is a crib-dam, with vertical face and sloping back, extending straight across the river, about 400 feet long, 8 feet high, and backing the water up to the Carbonton dam, 6 miles above, with an average width of pond of, say 300 feet. At one end is a grist-mill with 4 run of stones, using 8 feet fall and about 40 horse-power. The following table gives estimated flow and power, and, as in the former cases, it is probable that the power might, in low seasons, be increased to a considerable extent by drawing down the water in the pond during working hours:

Table of power at Gulf dam.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Per cent. of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*		*Feet.*	
Minimum	1,047	8	157	17.8	140	40	8	34±
Minimum low season			194	22.0	175			
Maximum, with storage			900	102.0	820			
Low season, dry years			222	25.0	200			

Carbonton dam is partly a frame dam, constructed of triangular wooden frames, set lengthwise up and down the river, and planked over, and partly a crib-dam, and is 300 or 400 feet long and 9 or 10 feet high, extending straight across the stream, and ponding the water for 6 miles, the average width being about 200 feet. The power is utilized for a grist-mill, saw-mill and cotton-gin, using about 35 horse-power and 10 feet fall. The available power is given in the table.

The last of the navigation dams is Hancock's, now called Tyser's, 12½ miles above Carbonton. It is of wood, 300 feet long and 10 feet high, with a pond 3 miles long and 200 to 300 feet wide. The power is used by a grist- and saw-mill and cotton-gin—a mill at each end of the dam—using 12 feet fall, and a total of some 60 or 70 horse-power. The available power is given below:

Table of power at Carbonton dam.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Per cent. of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*10 feet fall.*		*Feet.*	
Minimum	1,010	10±	150	17.0	170	35	10	28
Minimum low season			180	20.5	200			
Maximum, with storage			880	100.0	1,090			
Low season, dry years			206	33.5	235			

Table of power at Tyser's dam.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Utilized.		Per cent. of minimum utilized.
						Horse-power, net.	Fall.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*10 feet fall.*		*Feet.*	
Minimum	814	10±	123	14.0	140	60±	12?	57
Minimum low season			147	16.7	170			
Maximum, with storage			716	81.4	800			
Low season, dry years			168	19.1	190			

Carbonton is the head of navigation. The foundation of a lock was put in there, but the lock was never completed, so that boats never ascended into the pool of the Carbonton dam. I will now briefly mention and describe in order the remaining powers on the river, referring to the summary of power for estimates:*

1st. At Prosperity, Moore county, E. N. Moffitt's grist-mill; fall, 8 feet; 30 horse-power; dam, wood and stone, 275 feet long, 10 feet high.

2d. Big falls (belonging to N. D. Woody, Shaw's Mills, Guilford county), in Moore county, about 3 miles above Prosperity; unimproved. Said to be an excellent site, 12 miles from the proposed line of the Cape Fear and Yadkin Valley railroad and 23 miles from the Raleigh and Augusta Air-Line railroad. The fall has been estimated at 18 feet, with a 2-foot dam at head; length of shoal, three-eighths of a mile. The bed is rock, banks favorable; width of stream, about 350 feet.

3d. Unimproved privilege belonging to Elias Ritter, esq., Carter's Mills, Moore county. Fall unknown.

4th. Howard & Moffitt's grist- and saw-mill, Moore county, near the Randolph line. Stone dam, 310 feet long, 10 feet high, backing the water 3 miles. Fall utilized, 12 feet, and 30 horse-power at all times.

5th. Unimproved power, Randolph county; said to be 12 to 15 feet.

6th. Enterprise Manufacturing Company's mills, at Faust's Mills, Randolph county; stone dam, 300 feet long, 3 feet high, built in 1858 at a cost of $300, ponding about 18 acres. Head-race, 672 feet; fall utilized, 15 feet; horse-power used, 40. The company have a cotton-mill, saw-mill, and flour-mill. They say that they have an additional fall of 5 feet available, making 20 feet in all. There is always a waste of water.

7th. Unimproved site, 2 or 3 miles above Enterprise mills, known as the Cox falls, supposed to have a fall of 12 or 14 feet.

8th. Unimproved site, 4 miles farther up, known as the Allen falls, supposed to be 12 to 20 feet available, about 8 miles from the Cape Fear and Yadkin Valley railroad. Length of fall, about half a mile; rock bed and good banks.

*It may be stated here that most of the information regarding Deep river, in Randolph county, is due to the Hon. A. S. Horney, who furnished a long list of powers.

9th. Columbia Manufacturing Company (formerly Deep River Manufacturing Company). The dam is of stone, about 350 feet long and 12 feet high, built about 1850 at a cost of $2,000, backing the water 1¾ miles, with an average width of 300 feet. Head-race, 1,200 feet long; fall used, 12 feet at mills and 14 at factory, and about 100 horse-power in all. The company have a cotton factory, grist- and saw-mills, cotton-gin, and wool-cards, all driven from same dam and canal, the factory using about 70 horse-power. Water always wastes.

10th. Randolph Manufacturing Company, Franklinsville, 2 miles above Columbia Manufacturing Company. Dam of wood and stone, about 350 feet long, 8 feet high, giving a fall of 12½ feet, with a race of 450 feet; utilized power, 50 horse-power, which can be secured at all times. The mill is a cotton factory. In low water the water is drawn down below the crest of the dam, the mill being run during 12 hours.

11th. Franklinsville Manufacturing Company (cotton-bag factory, grist- and saw-mills, wool-carding machine, and cotton-gin). The dam is of stone, 350 feet long, 6 feet high; length of head-race 2,000 feet; fall utilized, 19 feet; power, 80 horse-power, which can be secured at all times by drawing down the water in the pond in dry seasons.

12th. Unimproved site, a mile or less farther up stream, said to have 15 to 20 feet available within a distance of rather over half a mile. Good location for a dam, with rock bottom and banks, known as the Reuben Aldred site. All accounts agree in stating this to be a valuable privilege.

13th. Grist-mill of Cedar Falls Manufacturing Company, about a mile above No. 12. Dam of stone and wood, 250 feet long, 8 feet high, ponding 2 acres, built in 1851 at a cost of about $6,000 (?). Length of head-race, 500 feet; fall utilized, 14½ feet; power used, some 20 to 30 horse-power; water always wasting.

14th. Cedar Falls Manufacturing Company's cotton factory, half a mile above grist-mill. Dam of stone and wood, 200 feet long, 6 feet high, built in 1836, costing $1,000. Pond, 1 acre; head-race, one-eighth of a mile; fall used, 25½ feet, and 60 horse-power at all seasons.

15th. Unimproved site, 1 mile above. Said to be 12 or 15 feet available.

16th. Central Falls Manufacturing Company's cotton factory, now building, 2 miles above No. 15. Fall said to be 12 feet.

17th. Cotton factory now building 2½ miles above No. 16; fall about 14 feet.

18th. Naomi Falls Manufacturing Company's cotton factory and grist-mill, 2 miles farther up. Fall about 10 or 11 feet; power used not stated; some steam used for power.

19th. Randleman Manufacturing Company. Three cotton factories, all from one dam, half a mile above No. 18. Dam is of stone, cemented and planked, 272 feet long and 10 feet high, built in 1878, costing $2,200. The pond is 2 miles long and 200 feet wide. Fall used, 11 feet; 125 horse-power obtained during 9 months by drawing down the water in the pond. Steam used to supplement water in low seasons.

20th. Unimproved site, called Island Ford, 2 miles above last power. Said to be 10 or 12 feet.

21st. Walker's grist-mill and saw-mill, 1 mile farther up. Dam of wood, 258 feet long, 8 feet high; fall used, 12 feet; power used said to be 20 to 25 horse-power.

22d. Unimproved site 5 miles above; said to be 10 to 12 feet.

23d. Coltrain's grist- and saw-mill.

24th. Freeman's grist- and saw-mill. Fine cemented rock dam; fall, 12 feet.

The powers above this are small, generally grist- and saw-mills, with one cotton factory at Jamestown, the Oakdale Manufacturing Company, using 19 feet fall and 70 horse-power during 10 months. During the remaining two months about 50 to 55 horse-power can be obtained by drawing down the water in the pond during the night, the mill being run 12 hours. The natural flow of the stream affords, therefore, about 2 horse-power per foot (gross) during the dry season of ordinary years, or the flow is about 17 cubic feet per second, and probably about 40 to 50 during nine months of the year. There are several sites not used, one of about 8 feet fall just below the cotton factory, and another of about the same several miles farther down.

Summary of power of Deep river.

[N. B.—The powers given in this table may, in most cases, be increased to a large extent, and perhaps doubled, if the mills are run only 12 hours and the water drawn down in the ponds at night.]

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross. †				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry year.	Horse-power, net.	Fall.		
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*						*Feet.*		
Lockville, lower dam	2. 0	1, 350	12	12	11	11	46	24. 0	2, 000	590	700	2, 950	800	150±	14–18	25±	Dam 11 feet.
Lockville, upper dam	2. 5	1, 350	12	12	11	11	46	16. 0		390	470	1, 950	525				Dam 16 feet.
Gorgas dam	5. 0	1, 300	12	12	11	11	46	7. 0		165	200	825	225	20	7. 0	18	Dam 7 feet.
Endor dam	11. 7	1, 075±	12	12	11	11	46	4. 0		70	90	400	100				Dam 4 feet.
Gulf dam	21. 7	1, 047	12	12	11	11	46	8. 0		140	175	820	200	40	8. 0	34	Dam 8 feet.
Carbonton dam	27. 7	1, 010	12	12	11	11	46	10. 0		170	200	1, 000	235	35	10. 0	28	Dam 10 feet.
Tyser's dam	40. 2	814	12	12	11	11	46	10. 0		140	170	800	190	60	12. 0?	57	Dam 10 feet
Prosperity mill	47. 0	784	12	12	11	11	46	10. 0		125	155	780	180	30	8. 0	30	Dam 10 feet.
Big falls	50. 0	746	12	12	11	11	46	18±	2, 000	210	250	1, 340	285	0			
Unimproved site			12	12	11	11	46										Fall not known.
Howard & Moffitt's mill	53. 0	665	12	12	11	11	46	12. 0		118	150	800	170	30	12. 0	32	Dam 10 feet.
Unimproved power			12	12	11	11	46										
Enterprise factory	63. 0	453	12	12	11	11	46	20. 0		112	150	925	170	40	15. 0	42	Dam 3 feet.
Unimproved site	65. 0	440±	12	12	11	11	46										
Unimproved site	68. 0	425±	12	12	11	11	46										
Columbia Manufacturing Company.	69. 0	420±	12	12	11	11	46	14. 0		70	100	600	115	60–100	12–14		Dam 12 feet; information conflicts.
Randolph Manufacturing Company.	71. 0	408	12	12	11	11	46	12. 5		55	70	500	80	50	12. 5	130	Dam 8 feet; water drawn down in pond.
Franklinsville Manufacturing Company.	71. 5	408	12	12	11	11	46	19. 0		85	110	800	125	80	19. 0	130	Dam 6 feet; water drawn down in pond.
Unimproved site	72. 5	400±	12	12	11	11	46	15+	3, 000+	70	90	600	105	0			
Cedar Falls Manufacturing Company.	73. 5	341	12	12	11	11	46	14. 5						20–30	14. 5		Dam 8 feet.
Cedar Falls Manufacturing Company.	74. 0	341	12	12	11	11	46	25. 5						60	25. 5		Dam 6 feet.
Unimproved site	75. 0		12	12	11	11	46										
Central Falls Manufacturing Company.	77. 0	300±	12	12	11	11	46	12±									Being improved.
Factory being built	79. 5	300±	12	12	11	11	46	14±									Being improved.
Naomi Falls Manufacturing Company.	81. 5	257	12	12	11	11	46	10±						(*)	10±		
Randleman Manufacturing Company.	82. 0	257	12	12	11	11	46	11. 0						125	11. 0		Dam 10 feet; full capacity 9 months.

* Not stated.

† See pages 18 to 21.

TRIBUTARIES OF DEEP RIVER.

The tributaries of Deep river are of small consequence, and only one of them is worthy of special mention, viz: Rocky river, which rises in the northwestern part of Chatham county and flows southeast, joining Deep river just above Gorgas dam. The stream is utilized to a considerable extent by small saw- and grist-mills, but, like other streams in the vicinity, it is subject to great variations in flow, owing to its course lying in the slate region. The drainage area of the stream is about 205 square miles, and its length, in a straight line, about 25 miles; yet during the dry season the flow is not sufficient to afford more than 20 or 25 horse-power, with a fall of 20 feet. There are 12 mills on the river, with falls of from 8 to 25 feet, but some sites are still unimproved.

The other tributaries above Rocky river are utilized for small grist- and saw-mills, but are not of much importance. Some of them are nearly dry in summer.

Table of utilized power on Cape Fear river and tributaries.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Cape Fear river	Atlantic	North Carolina	Cumberland		1	10.0	15
Northeast Cape Fear	Cape Fear	do	Pender	Flour and grist	1	7.0	10
Do	do	do	do	Saw	1	7.0	20
	Northeast Cape Fear	do	Duplin	Flour and grist	16	144.0	153
	Do	do	do	Saw	3	29.0	36
	Do	do	do	Cotton-gin	2	20.0	.....
South river	Cape Fear	do	Sampson	Flour and grist	1	7.0	8
Do	do	do	Pender	do	2	16.0	13
Black river	South river	do	Sampson	do	2	17.0	11
Do	do	do	do*	Cotton-gin	1	9.0	6
	Do	do	do	do	5	50.0	27
	Do	do	do	Flour and grist	11	115.0	98
	Do	do	do	Saw	1	....	10
All other tributaries to	Cape Fear	do	Bladen	Flour and grist	2	22.0	19
Do	do	do	do	Cotton-gin	1	8.0	3
Do	do	do	Cumberland	Flour and grist	10	95.0	150
Do	do	do	do	Saw	4	29.0	122
Do	do	do	do	Cotton-gin	3	....	.....
Do	do	do	do	Agricultural implements	1	20.0	12
Do	do	do	do	Cotton factory	5	72.0	348
Do	do	do	do	Woolen	2	....	.....
Do	do	do	Harnett	Flour and grist	13	155.5	158
Do	do	do	do	Saw	2	21.0	35
Do	do	do	Wake	Flour and grist	6	99.0	62
Do	do	do	do	Saw	1	11.0	18
Do	do	do	do	Cotton-gin	4	78.0	42
Do	do	do	Chatham	Flour and grist	2	30.0	30
Do	do	do	Moore	do	11	132.0	139
Do	do	do	do	Saw	6	88.5	118
Haw river	do	do	Chatham	Flour and grist	7	64.0	142
Do	do	do	do	Saw	2	14.0	35
Do	do	do	do	Wheelwrighting	1	7.0	10
Do	do	do	do	Cotton factory	1	16.0	80
Do	do	do	Alamance	Flour and grist	6	69.5	202
Do	do	do	do	Saw	2	25.5	46
Do	do	do	do	Blacksmith shop	1	11.5	30
Do	do	do	do	Cotton factory	5	73.5	505
Do	do	do	do	do*	2	26.5	.....
Do	do	do	Guilford	Flour and grist	2	27.0	21
Do	do	do	do	Saw	1	12.0	5
Do	do	do	Rockingham	Flour and grist	2	36.0	40
Do	do	do	do	Saw	1	18.0	20
Tributaries of	Haw river	do	Chatham	Flour and grist	13	179.0	176
Do	do	do	do	Saw	3	29.0	60
Do	do	do	do	Wheelwrighting	1	12.0	10
Do	do	do	do	Cotton gin	3	....	.....
Do	do	do	Orange	Flour and grist	8	161.0	188
Do	do	do	do	Saw	6	85.0	134
Do	do	do	do	Cotton-gin	1	....	20
Do	do	do	do	Millwrighting	1	14.0	12
Do	do	do	Alamance	Cotton factory	3	47.5	275
Do	do	do	do	Flour and grist	17	209.0	294
Do	do	do	do	Saw	4	52.0	77
Do	do	do	do	Cotton-gin	1	11.0	6
Do	do	do	do	Foundry	1	15.0	28
Do	do	do	do	Agricultural implements	1	16.0	[illegible]
Do	do	do	Guilford	Flour and grist	24	344.0	379
Do	do	do	do	Saw	6	79.5	93
Do	do	do	do	Woolen	1	12.0	.....
Do	do	do	Randolph	Flour and grist	1	19.0	10
Do	do	do	Rockingham	do	6	105.0	100
Do	do	do	do	Saw	3	54.0	48
Deep river	Cape Fear	do	Chatham	Flour and grist	4	41.0	112
Do	do	do	do	Saw	2	24.0	30
Do	do	do	do	Agricultural implements	1	16.0	15

*Being built.

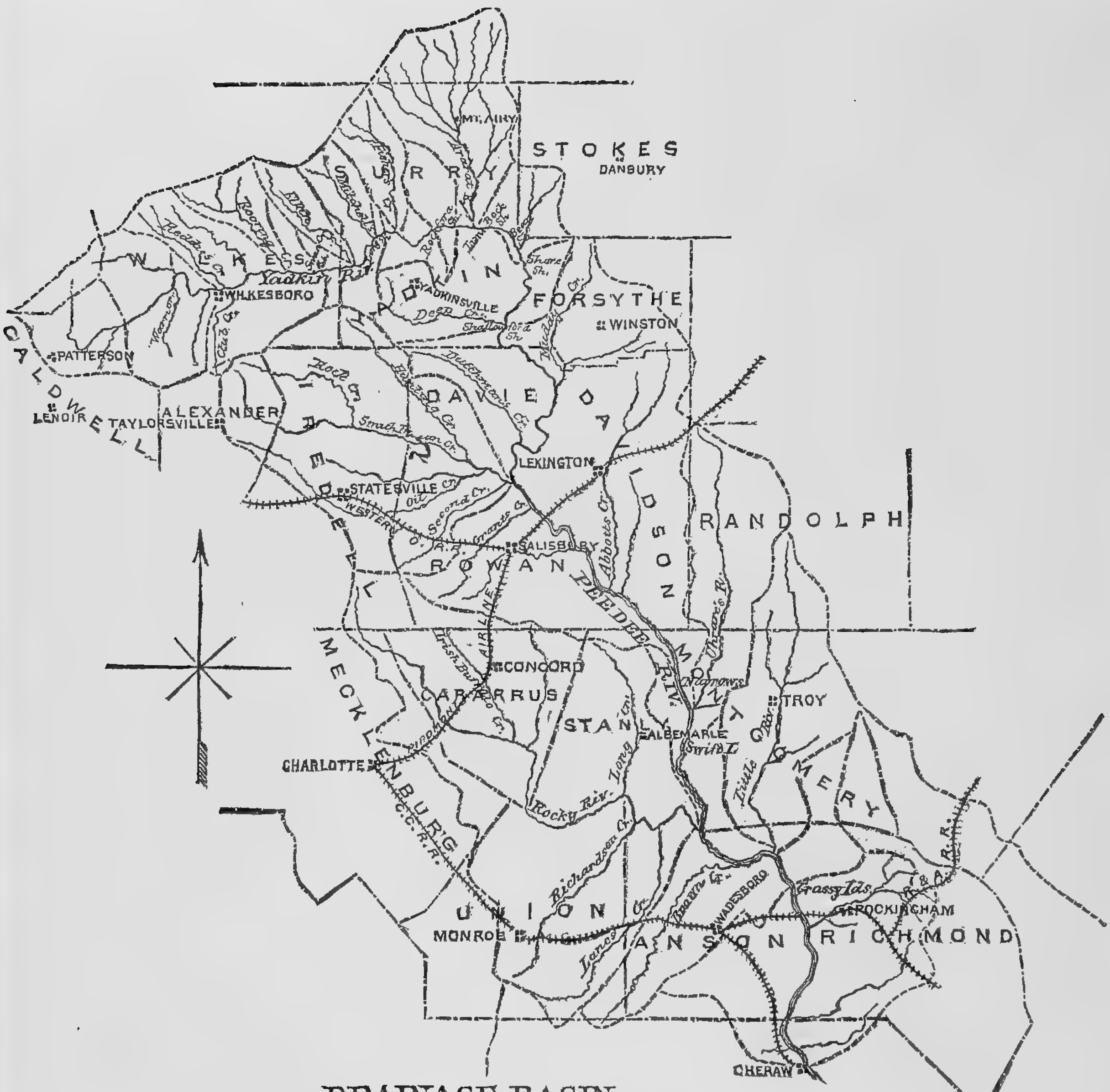
Table of utilized power on Cape Fear river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Deep River	Cape Fear	North Carolina	Chatham	Foundry	1	18.0	......
Do	do	do	do	Machine-shop	1	18.0	......
Do	do	do	do	Cotton-gin	1	14.0	......
Do	do	do	Moore	Flour and grist	3	32.0	120
Do	do	do	Randolph	Cotton factory	7	107.0	475
Do	do	do	do	do*	2	26.0	......
Do	do	do	do	Flour and grist	7	100.0	250
Do	do	do	do	Saw	1	12.0	12
Do	do	do	do	Woolen	2	....	50
Do	do	do	do	Furniture (?)	1	3.0	4
Do	do	do	Guilford	Flour and grist	7	92.5	124
Do	do	do	do	Cotton factory	1	19.0	70
Do	do	do	do	Saw	1	24.0	25
Do	do	do	do	Carriages	1	17.0	20
Do	do	do	do	Woolen	1	7.0	15
Tributaries of	Deep river	do	Chatham	Flour and grist	17	225.0	253
Do	do	do	do	Saw	3	45.0	69
Do	do	do	do	Agricult'l implements	1	9.0	10
Do	do	do	do	Leather	1	12.0	6
Do	do	do	Moore	Flour and grist	8	86.0	135
Do	do	do	do	Saw	4	42.0	74
Do	do	do	Randolph	Flour and grist	23	331.0	361
Do	do	do	do	Woolen	1	8.5	......
Do	do	do	do	Saw	8	106.0	128
Do	do	do	Guilford	Flour and grist	5	79.0	56
Do	do	do	do	Woolen	1	16.0	......

*Being built.

Table of drainage areas of Cape Fear river and tributaries.

	Square miles.
Cape Fear river at mouth	8,400
Northeast Cape Fear river at mouth	1,330
South river at mouth	1,430
Black river at mouth	620
Cape Fear river at Fayetteville	4,250
Cape Fear river at Jones' falls	4,170
Cape Fear river at Silver run	3,660
Cape Fear river at Smiley's falls	3,400
Cape Fear river at Buckhorn falls	3,200
Cape Fear river at forks	3,025
Haw river at mouth	1,675
Haw river at Bynum's	1,250
Haw river at North Carolina railroad	585
Haw river at Reedy fork	173
New Hope river at mouth	317
Alamance creek at mouth	237
Reedy fork of Haw at mouth	281
Deep river at mouth	1,350
Deep river at Lockville	1,340
Deep river at Gorgas	1,300
Deep river at Gulf	1,047
Deep river at Carbonton	1,010
Deep river at Tyser's	814
Deep river at Franklinsville	408
Deep river at Unionville	257
Rocky river at mouth	205
Rockfish creek at mouth	280
Little Rockfish creek at mouth	77
Little Rockfish creek at factory	55
Lower Little river at mouth	448
Lower Little river at Manchester	329
Upper Little river	176



DRAINAGE BASIN.
OF THE
PEE DEE RIVER,
ABOVE CHERAW.
Scale
10 20 30 40 50 Miles

VI.—THE GREAT PEE DEE RIVER (AND YADKIN) AND TRIBUTARIES.

THE GREAT PEE DEE RIVER.

The Great Pee Dee river takes its rise on the eastern slope of the Blue Ridge, in Caldwell and Watauga counties, North Carolina. It flows first a little north of east through Caldwell and Wilkes and between Surry and Yadkin counties, when it bends abruptly to the right, and flows a little east of south, forming the boundary between the counties of Forsyth, Davidson, Montgomery, and Richmond on its left, and Yadkin, Davie, Rowan, Stanley, and Anson on its right, passing into South Carolina, and continuing in the same general direction between Marlborough and Marion counties on its left, and Chesterfield, Darlington, Williamsburg, and Georgetown on its right, emptying into Winyah bay just at the town of Georgetown, after flowing for some distance through the county of the same name. The river is known as the Great Pee Dee only in that part of its course below the mouth of the Uwharrie river, in Montgomery county, North Carolina, being called the Yadkin above that point. Following the general course of the stream, the distance from its source to its mouth is between 275 and 300 miles, but following all its windings it is much greater—as nearly as I can estimate by measurement on the map, some 400 miles or more, and I think that it will be found in fact to be greater still.

There are no towns of great importance on that part of the river where there are any facilities for water-power. Georgetown, at the mouth of the stream, has a population of 2,557, and Cheraw, the head of navigation, 918. In North Carolina there are no towns on the river with more than a few hundred inhabitants, the principal one being Wilkesboro', the county-seat of Wilkes county.

The head of navigation on the river is Cheraw, South Carolina, about 149 miles above the mouth. By the act of Congress of June 14, 1880, the sum of $7,000 was appropriated to the work of improving the navigation on this part of the river, and it is hoped to secure 9 feet of water as high as Smith's Mills, 46 miles from the mouth, and 3½ feet at the lowest stage as far as Cheraw, the estimated cost of the whole improvement being $25,520. There is considerable trade upon the river as high as Smith's Mills, and vessels drawing 9 feet reach that place at a fair stage of the water. The principal shipments are cotton, lumber, and naval stores. There is at present a navigable depth of 3 feet in favorable stages of the water as high as Cheraw, and two steamers run regularly upon the river, ascending as high as this place when practicable. An examination of the river between Cheraw and the mouth of the Uwharrie, a distance of 67 miles, has also been made, and it is found practicable to render the river navigable as high as this point by locks and dams, but no appropriation has yet been made for the work. Above the mouth of the Uwharrie the "Narrows" form an insurmountable obstacle to navigation, but above them, between the North Carolina railroad bridge and Wilkesboro', the river has been surveyed, and an appropriation of $20,000 made March 3, 1879, the object being to secure a navigable depth of 2½ to 3 feet as high as the foot of Bean's shoal, a distance of 64.8 miles. There are some mill-owners in this distance with whom it has thus far been impossible to effect an arrangement "whereby the United States might be protected from claims for damages resulting from the prosecution of the improvement".* A second appropriation for this work of $20,000 was made June 14, 1880. The cost of the improvement is estimated at $82,000, and is to be effected without locks and dams.

The Great Pee Dee drains a total area of about 17,000 square miles, of which about 9,700 lie in North Carolina and 7,300 in South Carolina. The principal tributaries to the river are the Waccamaw river, from the north, draining about 1,200 square miles; the Black river, from the west, draining about 1,500 square miles; the Little Pee Dee river, from the north, with a drainage area of some 3,000 square miles; Lynch's creek, from the west, draining about 1,350 square miles; Black creek, from the west, draining about 450 square miles; Little river, from the east, draining 400 square miles; Rocky river, from the west, draining 1,400 square miles; Uwharrie river, from the east, draining 317 square miles; the South Yadkin, from the west, draining 820 square miles; and the Ararat river, from the north, draining about 315 square miles, besides numberless smaller streams and creeks affording fine water-power, especially in the upper part of the drainage-basin.

The Great Pee Dee crosses the fall-line a little above Cheraw. The fall is not so pronounced as in the case of the Tar and the Roanoke, consisting of a series of rapids extending over a number of miles, with no very great fall at any one place, or within any short distance. The drainage-basin of the river below the fall-line will be understood sufficiently well from the general description which has been already given of the eastern division, and of the lower parts of the Cape Fear and other rivers, while its general shape and dimensions may be seen from the accompanying map. Neither does that part of its drainage-basin lying above the fall-line differ in any essential particulars from that of the Cape Fear or the Roanoke, except that it reaches farther west (and into the mountains) than that of the Cape Fear. Below the great bend, where the river turns so abruptly to the south, its valley averages 50 miles wide, and at many points the river is bordered by wide and fertile bottoms, subject to overflow at times, and forming some of the best farming lands in the state, while at others the hills close in upon the river, leaving no bottoms at all, and

* Annual Report Chief of Engineers, U. S. A., 1880, App. H.

sometimes confining the river between steep and rocky banks on each side. In one case the river flows through a regular ravine, confined in a very narrow channel by bold and abrupt banks for a distance of several miles, forming the noted "narrows". Above the great bend the valley is narrower (only 15 to 20 miles wide), and the divides which separate the basin of the Yadkin from those adjacent are much higher, so that the tributary streams in the vicinity have a very large fall. The level land along the stream, however, is seldom in this part of its course over a mile wide, interjected between the spurs of the parallel ranges of mountains which form the divides, and forming in places extremely picturesque little valleys, surrounded on almost all sides by high mountains. Even in this part of its course the river rises above its banks in high water, although the grounds subject to overflow are not very extensive. Near Yadkinville the river passes through a gap in the mountains, and above that point its valley is flanked on the north by the Blue Ridge and on the south by the Brushy mountains, the divides having elevations of from 1,500 feet upward, and from these come pouring down many mountain-streams and torrents. The upper part of the valley of the Yadkin is very well wooded, and the mountains not being bare, the streams are more constant in flow than would be expected.

The facilities for the construction of storage-reservoirs are good on some of the tributaries, and on the main stream in the very upper part of its course. Below, they would, of course, be impracticable.

The products of the Yadkin valley are cotton, tobacco, corn, rice, wheat, oats, rye, clover and grasses, sorghum cane, vegetables, and fruits in the lower part, and principally grain, vegetables, and fruits in the upper part. Between the cool slopes of the Blue Ridge on the north and the low and hot plains of the eastern division on the south the range of production—as in the case of the Roanoke—is very large, the mountains being well adapted to grazing, the bottom-lands of the valleys to the raising of cereals, grasses, vegetables, fruits, and tobacco, and the low country along the lower part of the stream to the production of cotton and rice.

The river is subject to freshets, but I learned of no peculiarities concerning them. They are said not to be so violent, as a rule, as on the Cape Fear, Neuse, or Tar, probably because of the character of the upper part of the basin; and, although there are no lakes to regulate the flow, the extensive woods and the mountains, well covered with soil, serve to restrain their violence. Neither are the freshets so violent as on the Roanoke, the cause in this case being, probably, the fact that the rainfall in the upper valleys of the Yadkin is perhaps, on the whole, more uniformly distributed throughout the year than on the Dan and Staunton. At any rate, the highest flood ever known at Wilkesboro' occurred in September, 1878, yet the rise was only 23 feet above low water; and at Langenhour & Neason's mill the extreme high-water mark is at 22.9 feet. The floods are short, generally subsiding in from 36 to 48 hours. It is said that twenty-five years ago high floods very rarely occurred, and their frequent occurrence now is accounted for by the clearing of the hills and the removal of obstructions from the river.* The low grounds adjacent to the river are more frequently overflowed than formerly, and more damage is done to the crops.

The river sometimes brings down a good deal of ice, so that it cannot be ferried; still there is not very much difficulty on this account. The rise is sudden, the water sometimes rising, it is said, 2 feet in 20 minutes at Kirk's ferry (mouth of the Uwharrie).

The annual rainfall in the valley varies from 44 inches near the coast to 50 inches between Cheraw and the "narrows", and 44 to 50 above the latter point. The table on pages 82 and 83 gives more detailed information regarding the rainfall above the important powers, and of its distribution through the year.

The following table gives the elevations of the various points on the stream, distances, and declivity:

Table of declivity of Yadkin river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Mouth	....	....			
Cheraw, South Carolina	149	65	149	65	0.44
Crossing of Carolina Central railroad	169	105	20	40	2.00
Foot of "narrows", mouth of Uwharrie†	216	385	47	280	5.96
Head of "narrows"‡	220	490	4	105	26.25
Crossing of Piedmont Air-Line railroad§	256	591	36	101	2.81
Foot of Bean's shoal‖	321	722	65	131	2.01
Head of Bean's shoal‖	325	761	4	39	9.75
Wilkesboro' ‖	378	928	53	167	3.15
Patterson ¶	410	1,250	32	322	10.06

* Annual Report Chief of Engineers, 1879, p. 628.

† Report of Chief of Engineers, 1879, p. 725.

‡ From barometric observations.

§ From Professor Kerr's Geological Report.

‖ Report of Chief of Engineers, 1879, p. 626.

¶ For elevation at Patterson I am indebted to Maj. C. S. Dwight, chief engineer Chester and Lenoir railroad, and to L. C. Jones, Esq., chief engineer and superintendent of the Cape Fear and Yadkin Valley railroad.

I have only one measurement of the flow of the river, viz: that of Professor Kerr,* who states the flow (at low water) to be 2,586 cubic feet per second near the crossing of the Piedmont Air-Line railroad. But as the drainage area above this place is only 3,202 square miles, it seems impossible that this can be anything near the minimum, but probably nearer the ordinary flow. I have therefore had recourse to estimation of the flow.

One of the greatest drawbacks to the utilization of water-power on the Yadkin is the inaccessibility of the river. It is crossed in its water-power portion by only two railroads, and even these cross it almost at right angles, so that, as the map shows, hardly any portion of the river is of easy access. Various railroads have been projected along the river, and at present two are in course of construction or survey which will do much to open up the river and develop its resources. The Cape Fear and Yadkin Valley railroad, which at present extends only from Fayetteville to Egypt, on Deep river, will before long be extended, passing through Greensboro', and striking the Yadkin river some 10 or 12 miles southeast of Pilot mountain, near the southeast corner of Surry county, whence it will follow the valley of the Yadkin up to Wilkesboro' and beyond. The Chester and Lenoir railroad, now being built, runs from Chester, South Carolina, through Lincolnton and Lenoir, striking the Yadkin valley near Patterson, and will be continued across the Blue Ridge to Elizabethton, in eastern Tennessee. A road has also been spoken of up the valley of the Yadkin in the lower part of its course in North Carolina, passing the "narrows"; but I do not know that any steps have yet been taken toward obtaining a charter.

I proceed to describe the river more in detail, with its various water-powers, in order, commencing at its mouth.

Below Cheraw there is, of course, no power, and the river has the same general character as the Cape Fear below Fayetteville, so that it need not be described here.

Between Cheraw and the crossing of the Carolina Central railroad, a distance of 20 miles, the fall is at the rate of 2 feet per mile,† and the width of the river 350 to 500 feet. There are 11 shoals in this distance, but none of much importance, and none in themselves available for power, although, by the construction of a long canal, power might be secured. Such a plan would not, however, be advisable. At Cheraw the river is only 350 feet wide, and the greatest rise in freshets is 34 feet. The bed is generally rock and bowlders.

Between the Carolina Central railroad crossing and the mouth of Little river, a distance of 16 miles, there are two shoals which might be utilized. The first is Bluitt's falls, perhaps 5 miles above the railroad. A dam with a height of 9 feet is considered practicable here, and sufficient to render the stream navigable, so that 9 feet may be considered the available fall. This shoal is used by a small grist-mill and cotton-gin in Richmond county, using 6½ feet fall and some 12 horse-power. The dam is a primitive wing-dam. The second shoal is at Grassy islands, 10 miles above the railroad. This is really the first fall of importance on the river, and is probably at the crossing with the fall-line. The river is very wide and dotted with islands, and the banks are said to be favorable for the utilization of the power. In the engineer's report above referred to it is proposed to overcome the fall by four locks and dams, with 9 feet lift each, or 36 feet in all, but the distance in which this fall occurs is not stated. This shoal is utilized by a small grist-mill, using probably some 10 or 15 horse-power and a small fall. Three miles or thereabouts farther up is another similar mill. The total fall in the river between the railroad and Little river is estimated at 100 feet, and the width varies from 554 to 627 feet. The greatest rise on record at Little river is 19.77 feet. Between Little river and Rocky river, 11 miles, the fall is said to be about 60 feet, and there are several shoals, though their falls are unknown. Between Rocky river and Shankle's mill, 11 miles, the fall is about 65 feet, with several shoals. Thence to the mouth of the Uwharrie river, 9 miles, the fall is 55 feet; and in this section are two shoals, Swift Island shoal and Greenville's shoals, the former being 1 mile and the latter 2 miles in length. Swift Island shoal is the first place on the river where power has been used to any considerable extent, a cotton-mill, with 8 or 9 feet fall, being located here. The dam is of rock, 4 or 5 feet high, extending across the river in the form of a Λ, and a head-race about half a mile long leads to the factory, which is on the east side of the river, while on the west side was a grist-mill, run from the same dam, but burned a short time ago. There is also a grist-mill on the east side near the factory. Mills have been in operation here for 50 or 75 years. At present about 40 horse-power is used, and the mills are stopped by high water about 12 days in the year. The entire property is for sale. This place is about 8 miles east of Albemarle, the county-seat of Stanley county, and is about 27 miles from the nearest railroad station, Concord, on the Piedmont Air-Line. Before proceeding farther, it is to be remarked that, as the table of utilized power will show, there are various other small grist-mills on the river below Swift island with small falls and power.

At Gunsmith's shoal, just below the mouth of the Uwharrie, on the east side of the river, is Dr. Kron's grist-mill, using 4 or 5 feet fall, with a wing-dam. At the mouth of the Uwharrie the river is 1,155 feet wide, and the greatest rise is 12 feet.

Four miles above the mouth of the Uwharrie is, perhaps, the most remarkable power in the state, the "Narrows of the Yadkin." At the upper end, before entering the "narrows", the river is nearly or quite 1,000 feet

* Geological Report, page 40.

† Annual report of the Chief of Engineers, 1879, p. 725. From this report, on an examination of the river between Cheraw and the mouth of the Uwharrie, most of the following notes on that portion of the river have been taken.

wide, from which it suddenly contracts, entering a narrow ravine between the hills, which rise abruptly on either side with rocky and almost perpendicular banks, and through which it pours with great violence, preserving for a distance of over a quarter of a mile an average width of not over 75 feet, while in some places the width is only 30 feet. No description can do justice to this place, which is one of the most wonderful spots that can be found in the south. In the "narrows" proper—the quarter of a mile referred to above—the river has cut out its channel in the solid rock, the banks being almost perpendicular for a height of 5 to 15 feet above low water, when they retreat nearly horizontally, but very broken and rough, and with projecting points of rock, alternating with holes and crevasses, so that it is difficult and tiresome to make one's way along, for a distance of about 100 to 150 yards from the immediate channel, where the hills rise very steeply. Thus the average width of the ravine is in the neighborhood of 250 yards, or rather less, while the single channel of the river, through which its whole volume pours in low water, is 75 feet, and in places 30, in which the water is said to be very deep. The stream overflows its banks in freshets and fills the whole ravine, although it is very seldom that it covers all the projecting rocks. Below the "narrows" proper the stream widens to a width of 150 or 200 feet, and flows for the succeeding 2½ miles through a narrow gorge, the banks on either side being very steep and rocky all the way, except at one or two places, where small lateral valleys diverge, and where there is sometimes place to put a single mill. The real foot of the "narrows" is at the extremity of this 2½ miles, at which a small creek enters the river, and where the fall, which is very large all the way from the head of the "narrows", comes to an end. This place—the foot of the "narrows"—is called Little falls. Just below it comes a long and narrow stretch called the "Lake", the river being still confined between rocky and almost vertical banks, but the fall being very small, and the width of the stream only about 100 to 150 feet, the depth is very great. The banks slope down at a large angle straight into the river, and are of solid rock. At the lower end of the lake, which is between a quarter and a half mile long, the river widens, at a place called the Terrapin Hole, and thence down to the mouth of the Uwharrie, a distance of three-quarters of a mile or thereabouts, it is interspersed with rocks and islands, with banks 10 to 20 feet high on each side, and behind them flat lands for some hundred yards. Above the head of the "narrows" the banks on either side are moderately high, and behind them are fertile bottom-lands and hills. The fall at the "narrows" has never been accurately measured, and it was, of course, not possible for me to make any such measurements. In fact, it is said to be a difficult and tedious undertaking to attempt to follow the river from the head of the "narrows" to the lake. But through Professor Kerr, to whom I have already acknowledged my great indebtedness on various occasions, I was enabled to take some barometric readings at various points. Unfortunately, however, the barometer was in a state of rapid change when I was at the "narrows", and although I took measurements of the fall on two different days they agree poorly with each other. According to the best estimate I can make, the total fall between the head of the "narrows" and the mouth of the Uwharrie, a distance of 4 miles, is about 105 feet, and I am inclined to consider this result too small, rather than too great. This fall is distributed about as follows: At the entrance of the "narrows" there is a fall of 5 or 6 feet in about 150, according to measurements with a pocket-level; in the succeeding quarter of a mile—the "narrows" proper—the fall is not less than 30 feet, according to the barometer and the pocket-level; for the next 2 miles the rapids continue with a pretty uniform fall of about 50 feet in all; then comes Little falls, where the fall is 5 or 6 feet in 500 and 14 or 15 in 1,000, from the top of a mill-dam above the falls; at the falls the river is almost as narrow as at the "narrows", or about 60 feet in one place; below them comes the lake, etc., the fall down to the mouth of the Uwharrie being, perhaps, 5 or 10 feet.

According to what has been said, it will be seen that this magnificent power is, unfortunately, not available, or only to a very small extent. A dam could be built on the river above the "narrows", and the water carried along by a flume, the mills being located on the rocks; but while such a use of the power would be perfectly practicable, no one would think of locating a large establishment right in a gorge of the mountains, in such an inaccessible place and on the rocky banks of a river, where it is liable to overflow in times of high water. A canal could not be cut along the "narrows" except at very large cost; neither could it be carried around the hills, except with great difficulty. Below the "narrows" proper there is no horizontal bank, as there is at the former place; but the channel is wider and the banks slope down to the water's edge, so that to canal, or even to flume, around this part of the fall would be difficult. There are a few places, where lateral ravines make down to the river, at which the banks are not so abrupt, and where there is room for a single mill; and, in fact, one small grist-mill is situated in this part of the "narrows", near Little falls, being run from a small wing-dam, and using a fall of 6 or 7 feet; but there are no facilities for the location of a manufacturing town, or even of a large mill. There are no low grounds between the head of the "narrows" and the mouth of the Uwharrie. The rock in the "narrows" is a solid metamorphic conglomerate, very hard, almost impossible to fracture by ordinary blows, and certainly difficult to blast. Some power might be obtained by damming the river at the Terrapin Hole and throwing the water up over Little falls, or at Little falls itself a mill could be established; but a very small proportion of the total power at this place is practically available. When it is added that the site is 30 miles from Salisbury, the nearest railroad point, it will easily be concluded that it will be a long time before any endeavor is made to utilize the power to any large extent.

I have estimated the theoretically available power, with the result, in the following table, taking the fall at 105 feet. Of this total power probably not over 500 horse-power would be practically available without great cost, and even that, for the present at least, not economical, and only profitable for grist-mills:

Table of power on the "narrows" of the Yadkin.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*105 feet fall.*
Minimum	3, 940	*105±	866	98.4	10, 330
Minimum low season			1, 100	125.0	13, 125
Maximum, with storage			3, 350	380.7	39, 973
Low season, dry years			1, 250	142.0	14, 910

* See description.

Between the "narrows" and the railroad bridge there are several shoals, some of which are said to afford good power and considerable fall. They are used by small grist- and saw-mills, with wing-dams (Nash & Kirk's mill, west side; Redwine & Pemberton's mill, west side; Snotherly & Cooper's grist-, saw-, and wood-turning mill, east side), and in one case, at Milledgeville, by a cotton factory, together with a grist-mill, using, in all, some 40 horse-power. The dam at this place is of rock, about 600 feet long, and only a wing. On the opposite side of the river are a saw-mill, grist-mill, cotton-gin, and wool-carding machine, also run from a small wing-dam across to an island. The stoppage by backwater is from six to ten days in the year.

Above Milledgeville there are still several shoals and mills, viz: Mott's falls, not used; Reed's and Bald Mountain mills, on opposite sides; a mill on each side at Bringle's ferry; St. John's mill, 1 mile below the bridge. In regard to all these I have no particulars. They are tabulated in the table of utilized power, and it will be seen that the falls are small as a rule, though there is one fall of 28 feet put down in Montgomery county. But as I have no other mention of such a fall, I am inclined to think it must be on some tributary.

As showing the topography of this region, and how the Yadkin descends from an elevated plateau, while one of its tributaries, the Uwharrie, flows along the base of the same, it may be mentioned that according to a railroad survey (the line of which crossed both rivers) the elevation of the Yadkin at Stokes' ferry, about 10 or 11 miles above the mouth of the Uwharrie, was 190 feet greater than that of the latter stream at about the same distance from its mouth, so that the fall of the Yadkin must be at least 200 feet within the distance mentioned.

Above the railroad bridge the river has been surveyed in detail by Mr. S. T. Abert, United States civil engineer, to whose report, published in the *Annual Report of the Chief of Engineers*, 1879, pp. 626–648, I must refer for more detailed information regarding the stream, which I did not visit in this section. Mr. Abert's survey extended as far up as Wilkesboro', and the shoals in that distance are tabulated farther on. The following notes regarding them are taken principally from his report:

Below Bean's shoal there are several small grist-mills on the stream, using very primitive wheels and little power; and several other mills, not mentioned in the table of power, have been operated at different times. The first mill of much importance is Langenhour & Neason's, and the dam is the first one which extends entirely across the river, except Swicegood's, about 20 miles below—a low wing-dam of stone. It is built of wooden frames planked over, and the foundation is rock.

At Shallow Ford shoal there is a grist-mill on the right bank, with a wing-dam.

The principal shoal on this part of the river is Bean's shoal, the fall in 4 miles being over 39 feet. The most rapid descent is at the head, being nearly 17 feet in a mile. The bed of the stream is very ragged, of stratified rock, which rises in sharp points and ridges at right angles to the course of the river, forming in some places natural dams, extending nearly across, and the channel is much obstructed and cut up with rocks and islands. Between 1820 and 1835 "the Yadkin Navigation Company did considerable work at these shoals, with a view to rendering the river navigable. A dam was built at the head of the shoals, and a canal commenced along the northern side of the river. The only trace of the dam now to be seen is the abutment at the entrance to the canal. The canal was completed for a little more than a mile from the head of the shoals, and was 15 to 45 feet wide at the bottom. Where the cliff forms one wall the minimum width is 15 feet. At 2,000 feet from the head of the canal are the ruins of a guard-lock 12 feet wide. The canal walls are of earth, except along the foot of the cliffs. Here a very good retaining-wall was built of *stone quarried on the spot.* The upper wall, 700 feet in length, was built of headers and stretchers, neatly pinned with small stone, and is in good condition. The outer face has a batter of $2\frac{3}{4}$ inches to the foot rise. The inner face was left rough, and covered with gravel and earth. No cement was used in its construction. The dimensions are: height, 6 to 20 feet; top width, 2.5 feet; bottom width, about 7 feet. The lower

wall, about 400 feet in length, is of the same general character, but in some places has been torn down to obtain stone for the construction of fish-dams. The canal has been filled in by the floods, and where it runs through the woods is overgrown with trees and bushes. No water flows through it".

The other shoals mentioned call for no special remark. The bed of the stream is everywhere rock, overlaid sometimes with gravel, and is most favorable to the construction of dams. Beside the shoals mentioned in the table there are many others with smaller falls, but which might equally well be used for power. As regards the amount of power available, there is no doubt that it is very large indeed, and that almost every one of these shoals might be utilized to a greater or less extent. Bean's shoals would seem to offer the most excellent site in this part of the state, and it having been considered practicable to build a canal around the whole shoal it would seem to follow that the power might be utilized without much difficulty. While the estimates of power given in the table are only to be regarded as rough approximations, it is believed that they will serve to give some idea of the amount of power which might be obtained. But until larger establishments seek a location in this vicinity, and until the means of transportation are improved, the water-power of the smaller tributary streams will be preferred to that of the main river, on account of the smaller cost, the (in general) safer location, and the diminished liability to stoppage by high water. But when large amounts of power are wanted, and money is at hand to develop it, the Yadkin will, no doubt, be found to afford a large supply.

Above Wilkesboro' the fall of the river continually increases, and there are some sites for power, but regarding them I could procure no detailed information. The only power utilized is at Patterson, Caldwell county, where Gwyn, Harper & Co. have a cotton-mill, using, as they estimate it, 50 horse-power and a fall of 25 feet. The dam is of rock, 130 feet long and 20 feet high, built in 1850 at a cost of $500, and backing the water a quarter of a mile, without throwing the river out of its banks; and from it a race 630 feet long leads to the mill. There is no trouble with scarcity of water, and there is waste at night even at low water, the mill running 12 hours; so that the capacity of the stream here is at all times at least 2 horse-power to the foot fall, if the above data have been correctly reported. But as the drainage area above this place is very small, according to the map only 30 or 40 square miles, I should estimate the capacity of the stream at only about 1 horse-power, net, per foot fall. If the data returned are correct, it must be that there are large springs in the upper part of the basin, rendering the flow very large.

Above this the stream is rapid—a mountain stream, with very little, if any, power used.

It may be remarked that there are only three dams extending entirely across the river, all above the "narrows".

The estimates of power given in the following table are liable to large error, and it is impossible to check them. All of the powers used seem large in comparison with the drainage areas above them, as in the case of the one at Patterson, and it seems probable that the streams in the upper part of the basin are fed by large springs, which render the flow comparatively constant. I have therefore made my estimates larger than I should do in ordinary cases, and they may be found too large. It is to be remarked, however, that powers are often overstated, and that turbine-wheels are rated very high as regards efficiency. A power of 50 horse-power at Patterson, with a fall of 25 feet, would correspond to a flow at all times of 0.6 cubic feet per second per square mile. In the *Hand-book of North Carolina*, published by the Department of Agriculture, it is stated that the factory there has 18 looms and 960 spindles.

Summary of power of the Yadkin river.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.†				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*						*Feet.*		
Bluitt's falls	174.0	6,650	12	12	11	13	48	9.00	....	1,500	1,900	5,780	2,170	15–	6.50	1.2–	
Grassy Island shoal	180.0	6,624	12	12	11	13	48	36.00	....	5,970	7,600	23,000	8,680	25–	......	0.5–	
Swift Island shoal	212.0	4,323	12	13	11	14	50	9.00	*1	970	1,240	3,760	1,400	40	8–9	6.0±	
Narrows	220.0	3,938	12	13	11	14	50	105.00	*4	10,330	13,125	39,973	14,910	60–	6–7	0.6–	Not available.
Douthet's mill	291.5	1,865	13	14	10	14	51	3.86	1,600	190	245	720	280	25–	3.86	14.0–	Rock bottom.
Langenhour & Neason's dam	298.5	1,827	13	14	10	14	51	4.57	....	220	280	840	325	20–	5.00	15.0–	Do.
Shallow Ford shoal	305.0	1,812	13	14	10	14	51	7.89	5,560	375	485	1,440	550	6	11(?)	4.0–	Rock and gravel bottom.
Shoal above Shore's island	315.2	1,633	13	14	10	14	51	7.73	9,662	330	430	1,260	490	......	......	....	Do.
Bean's shoal (head)	324.7	1,521	13	14	10	14	51	39.17	*4	1,560	2,030	5,960	2,320	25–	......	3.0–	Rock bottom.
Lime Rock shoal	329.3	1,165	13	14	10	14	51	10.62	*2.59	325	425	1,240	490	......	......	....	Do.
Shoal below Rockford	335.8	1,097	13	14	10	14	51	8.38	4,500	240	320	920	300	......	......	....	Do.
Seven Island shoal	337.6	1,066	13	14	10	14	51	4.02	2,630	112	145	425	165	......	......	....	Do.

* Miles. † See pages 18 to 21.

Summary of power of the Yadkin river—Continued.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.†				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Feet.*						*Feet.*		
Long shoal	342.0	949	13	14	10	14	51	11.18	*1.61	265	335	1,140	385	......	......	......	Rock bottom.
Woodruff's Fish-trap shoal	345.0	925	13	14	10	14	51	4.55	1,800	105	134	450	155	......	......	......	Do.
Mitchell's Island shoal	346.6	925	13	14	10	14	51	4.00	2,740	90	115	400	135	......	......	......	Gravel bottom.
Swan Creek shoal	356.7	739	13	14	10	14	51	5.40	3,160	100	125	450	145	......	......	......	Rock bottom.
Reeve's Island shoal	366.5	540	13	14	10	14	51	3.86	2,700	50	65	240	75	......	......	......	Rock and gravel bottom.
Blair's Island shoal	376.5	420	13	14	10	14	51	3.44	1,700	36	46	170	53	......	......	......	Gravel bottom.
Total between—									*Miles.*								
Cheraw	149.0	7,175	12	12	11	13	48	320.00	67	44,500	56,500	170,000	64,600	300±	......	1.0—	
and mouth of Uwharrie	216.0	3,938															
Total between—																	
Mouth of Uwharrie	216.0	3,938	12	13	11	14	50	206.00	40	18,000	23,000	69,500	26,300	200—	......	1.5—	
and railroad bridge	256.0	3,202															
Total between—																	
Railroad bridge	256.0	3,202	13	14	10	14	51	131.00	65	6,675	8,700	25,500	10,000	200—	......	5.0—	
and foot of Bean's shoal	321.0	1,500															
Total between—																	
Foot of Bean's shoal	321.0	1,500	13	14	10	14	51	206.00	57	4,600	5,900	20,000	6,750	40—	......	1.5—	
and Wilkesboro'	378.0	372															
Total between—																	
Wilkesboro'	378.0	372	13	14	10	14	51	322.00	32	1,600	1,925	8,000	2,200	......	......	......	
and Patterson	410.0	30															
Total on river between—																	
Cheraw, South Carolina	149.0	7,175	....	....	....	....	....	1,185.00	261	75,375	96,025	293,000	109,850	736	......	1.4—	
and Patterson, North Carolina.	410.0	30															

* Miles. †See pages 18 to 21.

TRIBUTARIES OF THE YADKIN.

The lower tributaries of the Great Pee Dee, viz: the Waccamaw, the Black, and the Little Pee Dee rivers, scarcely call for a detailed description. Lying entirely below the fall-line, their general character will be sufficiently clear from what has been already said regarding similar streams, and regarding the eastern division, as a whole, in the introduction. The Waccamaw rises in Waccamaw lake, Columbus county, North Carolina, not over 25 miles from the Atlantic, and flows for a distance of 244 (?) miles nearly parallel to the coast, joining the Great Pee Dee at its mouth. It is navigable for light-draught steamers for 163 miles, and for boats drawing 3 feet of water up to the lake. Its water-power, and that of its tributaries, does not amount to much. The Black river, which has its sources in Kershaw and Sumter counties, South Carolina, is similar in character, and has no water-power, except a little in the upper part, among the sand-hills. The Little Pee Dee, which unites with the Great Pee Dee 23½ miles above its mouth, is more important. Rising in Richmond county, North Carolina, it flows in a general southerly course, as will be seen from the map, its length along its general course being about 75 miles, but much greater by the river, which is quite crooked, like all the streams in the low region near the coast. The total drainage area of the river is about 3,000 square miles, and it receives one tributary larger than itself, the Lumber river, from the east and north, which drains nearly 1,800 square miles. The sources of the Little Pee Dee are just about on, or a little below, the fall-line, in the sand-hills; and they therefore afford some power, their general character being the same as that of the sand-hill tributaries of the Cape Fear, which has been described on page 61. Their declivities being uniform, no sites could be specified. Gum Swamp creek will serve as a sample of these streams. There is a cotton factory, saw- and grist-mill at Laurel Hill, on this stream, the fall being 8½ feet, and the power for the factory 44 horse-power, and in all, perhaps, 60 or 65 horse-power, which can be obtained all the time by drawing down the water in the pond, which covers 200 acres, during working hours. The dam is of dirt and timber, 7 feet high, and the head-race 1½ miles long. As already mentioned, the constant flow of these streams, and the large ponds possible, render them valuable for power.

The Lumber river has its sources higher up than those of the Little Pee Dee, in Montgomery and Moore counties, North Carolina, but reaching little, if at all, above the fall-line. Its character resembles that of the Little Pee Dee, and on its upper part it probably belongs to the class of sand-hill streams. There are no mills, except small saw- and grist-mills, on the main stream, or on any of its tributaries.

Lynch's river rises in the extreme southern part of Union county, North Carolina, and flows in a southeasterly direction through South Carolina, between the counties of Lancaster, Kershaw, Sumter, and Clarendon, on its right, and Chesterfield and Darlington, on its left; thence through Williamsburg, to join the Great Pee Dee, about 16 miles in a straight line, above the mouth of the Little Pee Dee. It has its sources a considerable distance above the fall-line. The stream is about 120 miles long, following its general course, but probably twice as long by the river, and its drainage area comprises some 1,350 square miles. In its lower parts the banks are low and swampy, and it is only in that part which lies above Sumter county that the stream is worth anything for power. But although its sources lie above the fall-line, I was unable to learn of any important shoals on the stream, and the utilized power is quite insignificant, consisting only of that used for a few grist- and saw-mills. Between Kershaw and Chesterfield counties the stream crosses the sand-hill belt, and many of its tributaries in those counties afford good small powers, the principal affluent being Little Lynch's creek, from the west, taking its rise in Lancaster and joining the main stream in Kershaw county, after draining an area of about 170 square miles, and being utilized for a few small grist-mills. The beds of these streams are of rock down to the fall-line, or about the lower end of Lancaster county, below which they are sand and alluvium. The mills on these streams have sometimes as many as four run of stones, but in summer they are often obliged to run a smaller number. The dams are generally wooden triangular frames, set lengthwise up and down stream, and planked over. Lynch's river is navigable for a considerable distance from its junction with the Pee Dee. The freshets on these streams are not very heavy, and there is no trouble in keeping dams in order.

The Great Pee Dee receives in South Carolina several other tributaries resembling Lynch's river, such as Black creek, which rises in Chesterfield county and joins the river in Darlington; Crooked creek, from Marlborough county; and a creek from Chesterfield county, which empties a few miles below Cheraw. These streams need not be described, because they resemble, in every particular, the streams below the fall-line, which have already been referred to. In the upper parts of their courses they flow on the sand-hill belt, and afford, as a rule, good constant powers, but with no natural falls, and with a uniform declivity, all the power used being obtained by damming.

The first tributary worth mentioning in North Carolina is Hitchcock's creek, although there are several streams below it which are also favorable for power. Hitchcock's creek flows entirely in Richmond county, and has a length, in a straight line, of only about 16 or 20 miles, draining an area of some 102 square miles. It receives one tributary from the south—Falling creek—worth mentioning on account of its utilized power, although it is a small stream, with a drainage area of only about 12 square miles. At the junction of these two streams is the town of Rockingham, the county-seat of Richmond county, with a population of about 1,600. These streams are true sand-hill streams, so that for their general character we may refer to page 61. Falling creek, however, differs from the ordinary sand-hill streams by having a large natural fall near its mouth, which may be its crossing with the same ledge of rocks which forms the fall-line. Both streams are used to a considerable extent to drive saw- and grist-mills, as will be seen from the table of utilized power. They are principally remarkable, however, as running two of the largest cotton factories in the state, and they thus offer a good example of the large amount of power which may be obtained from these unpretending little sand-hill streams. The factory of the Pee Dee Manufacturing Company is located on Hitchcock's creek at Rockingham, and uses 168 horse-power, with a fall of 17 feet. The dam was built in 1875, at a cost of $3,000, and is of wood for 80 feet of its length and of earth for the remaining 100 feet. It is 17 feet high, and ponds the water over 100 acres to an average depth of 14 feet, affording reservoir-room sufficient to allow of the water being drawn down during working hours without diminishing the head much, and thus allowing of the concentration into working hours of the whole daily capacity of the stream. Full capacity can be secured all the time, except for a few weeks in summer, when the available power is only about 112 horse-power. The wheel used is a Hercules turbine (Holyoke Manufacturing Company).

On Falling creek is located the factory of the Great Falls Manufacturing Company, using 112 horse-power and a fall of 43 feet. The dam was first built in 1869, rebuilt in 1879, costing about $2,000, and is of wood, 100 feet long and 16 feet high, ponding the water over 10 or 12 acres to a depth of 10 feet. A wooden race, 75 feet long, leads the water to the wheels. As in the case of the other factory, the water is stored during the night. Full capacity can be secured for ten months, and two-thirds capacity during the remaining two months. During dry summers between two and three weeks are lost on account of want of water, and sometimes as much as four or five weeks.

It is interesting to calculate the amount of water which may be depended upon from these sand-hill streams, as was done in the case of the tributaries of the Cape Fear, but the inaccuracy of the available maps renders the result liable to error to an uncertain extent. The drainage area of Hitchcock's creek above the factory is, according to the map, about 86 square miles. If we assume that in the low season of dry years 100 horse-power (gross) may be obtained with a fall of 17 feet during 12 hours, or 50 with the natural flow of the stream, then the flow will be about 0.3 cubic foot per second per square mile. If we assume that 224 horse-power (gross) can be obtained at ordinary stages of the stream by drawing down the water at night, then the flow will be 0.7 cubic foot per second per square mile. For Falling creek, if we take the capacity at low seasons at 70 horse-power (gross) during 12 hours, we find the corresponding flow to be over half a cubic foot per second per square mile, or more than in the case of

Hitchcock's creek; and if the capacity in ordinary seasons be taken at 150 horse-power (gross) during 12 hours, we obtain a flow of over 1 cubic foot per second per square mile. It would therefore seem that these sand-hill streams discharge from one-third to 1 cubic foot per second per square mile of drainage area, except during freshets. (Compare the remarks on pages 64 and 65.)

Below Rockingham there have been four mills on the creek, two of which (Wall's and Acock's) are not in operation. There is also one other site not used just below Acock's mill, and above Rockingham there are three others. On Falling creek there are no mills of importance except the factory. The fall of the stream from the foot of the Great Falls dam, on Falling creek, to the Pee Dee, a distance of $5\frac{1}{4}$ miles, is 41 feet, or about 8 feet to the mile. The pond of the Great Falls factory is about 187 feet above tide, and the mouth of the creek 103 feet. The fall is said to be just as great for several miles above Rockingham.

The tributaries to the Pee Dee from Anson county are not of much value for water-power, as they appear to lie above the sand-hill belt, and are said to be very variable in flow. They are used only for small grist- and saw-mills, which often have to stop in dry weather. Little river, which rises in the southern part of Randolph county and flows south through Montgomery and into Richmond, joining the Pee Dee above Grassy Island shoal, is the next tributary worthy of mention, although its water-power is not of much importance. The length of the stream is about 40 miles in a straight line, and it drains an area of about 400 square miles. None of its tributaries are of any importance. It passes within a mile or so of Troy, the county-seat of Montgomery county, but there are no large towns directly on its course. Its fall is not large, and its flow is said to be very variable—very much more so than that of the sand-hill streams just discussed—and it is much more subject to freshets. There are only a few small saw- and grist-mills on the stream, and although it was said that there are some sites for power, especially on its upper parts, none of them are of importance. The mills in use have 2 or 3 pair of stones and falls of from 6 to 10 feet, generally with a dam of about the same height. I would estimate the flow of the stream at about 50 cubic feet per second at a minimum, and 90 or 100 in the low season of *ordinary* years. The rainfall is about 46 inches, 12 in each season, except autumn.

The next important tributary is Rocky river, which rises in the southern part of Iredell county, flows in a general southeasterly direction, making, however, several abrupt bends, and passing through Mecklenburg and Cabarrus counties, and then between Stanley on the north and Union and Anson on the south, its total length along its general course being about 75 miles, and its drainage area 1,405 square miles. The stream receives a number of considerable tributaries, viz: from the south and west, Lane's creek (140 square miles), Richardson's creek (199 square miles), and other smaller ones; and from the north, Long creek (158 square miles), Irish Buffalo creek, Coddle creek, and others. There are no towns of importance on the stream. As the drainage-basin lies entirely above the fall-line, the stream offers some power. The bed is rock, and in freshets the stream often rises over its banks. The power utilized is for small saw- and grist-mills and a cotton factory. The grist-mills have generally 2 run of stones, which they can run almost all the time, although the flow of the stream is said to be quite variable. The cotton factory, which is located not far from Concord, uses probably not over 25 horse-power with a fall of 13 feet, and can run all the time. I visited no particular sites on the river, none having been brought to my notice. The information which I was able to collect is very meager, but it seems probable that there is not very much power on the stream. I would estimate the flow at its mouth at between 400 and 500 cubic feet per second in the low season of ordinary years. The rainfall is about 50 inches.

The Uwharrie river, which enters the Yadkin in Montgomery county just below the "narrows", rises in the northwestern part of Randolph county, and pursues a course nearly due south through that county and Montgomery, its length in a straight line being about 37 miles, and its drainage area 317 square miles. It passes by no important towns, and has no large tributaries. Its water-power is not considered valuable, and is only used for country saw- and grist-mills, having generally 2 run of stones. The bed is rock, and the banks generally tolerably high on the lower part, though the low grounds are more extensive on the upper parts. There are no falls on the stream, and all the power has to be obtained by damming. The stream is, on the whole, rather sluggish, having a small fall, and crossing the ledges of rock at small angles, as has been noticed when speaking of the "narrows" of the Yadkin. Its flow is exceedingly variable—in fact, the stream is said to become nearly dry in summer—due, perhaps, to the fact that it comes out of the slaty region, which has been referred to when speaking of the Deep river. On this account its water-power is of small value, and the mills have often to stop in summer. The lowest mill is about 6 miles from the Yadkin, below which the fall is very small. A short distance above it is an old site, now not used, but probably not of much value. The freshets are heavy and sudden, as is to be expected in the case of a stream from the slate region.

Above the Uwharrie there are several small streams in Rowan and Davidson counties, but they are hardly worthy of special mention, being utilized only by saw- and grist-mills, and are, as a rule sluggish, with no fall or available power of much importance.

The next important affluent is the South Yadkin river, which rises in the southern slope of the Brushy mountains, in Alexander county, and flows a little south of east through Iredell, and between Davie and Rowan counties, joining the Yadkin a little above the railroad bridge, its total length in a straight line being about 42 miles, and its drainage area 820 square miles. Two of its tributaries from the north are worth naming, viz:

Hunting and Rocky creeks, which drain respectively 146 and 94 square miles. The bed of the stream is rock, overlaid in places by detritus; the banks moderately high, although overflowed in places in times of freshet; the fall considerable, and the flow more constant than in the case of any of the tributaries thus far mentioned above the sand-hill belt. The power of the stream and of its tributaries is utilized to a considerable extent by saw- and grist-mills and a few cotton factories, as will be seen by the table of utilized power. The first mill on the stream is 4 miles from its mouth, at South river (Foard & Lindsay's), and has a fall of 6 feet, with a dam of the same height and about 240 feet long. About 30 horse-power is utilized, but the available power is much greater. The drainage area above being about 800 square miles, I would estimate the capacity at perhaps 18 horse-power per foot fall in very dry seasons, and at 27 to 30 in the low seasons of ordinary years. This mill is sometimes troubled with backwater. The dam backs the water about 3 miles, nearly up to the foot of the next power above, Hairston's or Perkins' shoal. This shoal is the most important one on the stream, and is some 12 miles from Salisbury, and above the mouth of Third creek. The stream has, with a dam 3½ feet high, a fall of 15 or 16 feet in a quarter of a mile, but the principal part is at the upper end, being 13 or 14 feet in 200 yards. There was at one time a race cut on the north bank to the foot of the shoal, a quarter of a mile long, and along it were a foundry, a woolen-mill, and a grist-mill. At present there is a race 200 yards long, at the end of which is a grist-mill, with a fall of 13 feet, and there is also a saw-mill 50 yards from the dam with a fall of 12 feet. The power used is probably not over 40 horse-power. The dam, which extends entirely across the stream, is 250 feet long, 3½ feet high, built of wood about eleven years ago at a cost of $1,250, and backing the water for a mile or so, it is said. The location is an excellent one—safe, and with good facilities for canals and buildings. The practically available fall being taken at about 13 feet, and the drainage area above being in the neighborhood of 591 square miles, I would estimate the power about as follows:

Table of power at Hairston's Falls, South Yadkin river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*13 feet fall.*
Minimum	591	13	118	13.4	175
Minimum low season			148	16.8	220
Maximum, with storage			560	63.6	825
Low season, dry years			168	19.1	250

Above this shoal there are no mills for a long distance, and there are no important powers. On the upper part of the stream there are small mills, but none worth mentioning.

The tributaries to the South Yadkin afford some very good small powers. Second, Third, Fourth, and Fifth creeks, from the south, are all utilized to a greater or less extent by small mills, but are not very favorable; and Bear, Hunting, Rocky, and Snow creeks, from the north, are also used. Hunting creek has a cotton factory at Eagle Mills with a fall of 18 feet and 60 horse-power, it is said, the dam being 3½ feet high, and the race 400 feet long. This stream is said to offer a number of sites not used, and it is probable that the tributaries from the north all have a much greater fall than those from the south. Hunting creek drains an area of about 146 square miles, and the area above the factory is about 100. I would estimate the power at the factory at between 2 and 3 horse-power gross per foot fall in low seasons of ordinary years—nearer 3 than 2—or perhaps 40 horse-power net, with 18 feet fall and a good motor. The amount of power actually used in the factory is uncertain. Rocky creek has also a cotton factory at Turnersburg, using a fall of 19 feet and about 80 horse-power during ten months, and 60 during the remaining two. The drainage area is about 88 square miles above the factory and 94 at the mouth of the stream. This stream is similar in character to Hunting creek.

The tributaries to the Yadkin from Forsyth, Davie, and Yadkin counties are not worthy of special mention, as they are small, and in some cases very sluggish, offering no powers of importance. In Surry and Wilkes counties we come to a number of streams which rise in the Blue Ridge and pursue a southerly course to the river, draining a country very well wooded and having a very considerable fall. In Wilkes county there are also a few streams of this class which rise on the south, on the northern slope of the Brushy mountains, and flow nearly north. All of these streams are said to afford numerous excellent sites for power, only a few of which are at present utilized. They flow over rocky beds, with banks generally favorable for the construction of dams, and their flow is said not to be very variable. They are bordered with fertile and cultivated bottom-lands. Their drainage areas are given in the table on page 87, and as I was unable to visit this part of the state on account of its inaccessibility I cannot present much detailed information regarding them. The brief notes which follow below comprise all that I was able to collect. The rainfall over all this upper part of the Yadkin valley is about 51 inches—13 in spring, 14 in summer, 10 in autumn, and 14 in winter. As regards the flow of the streams, I do not present any detailed estimates, because they are liable to be too far out of the way. According to all the information which could be obtained regarding power utilized, the flow must be large compared with other streams of similar drainage area

thus far considered. I would be inclined, however, to estimate the flow in the low season of ordinary years at between 0.20 and 0.35 cubic foot per second per square mile of drainage area, varying between these figures for drainage areas between 30 and 300 square miles in area.

The first of these streams met with is the Little Yadkin, which flows south from Stokes county, and is not very important. The next, and the largest of them all, is Ararat river, which has its source in Patrick county, Virginia, and flows south through Surry, draining 315 square miles. It is said to be a very fine stream for power, and is utilized for saw- and grist-mills, and for a cotton factory at Mount Airy, with a fall of 13 feet and 20 or 30 horse-power. On its tributaries there are also a few woolen-mills, and there are said to be numerous sites not utilized. The remaining tributaries in Surry county are Fisher's and Mitchell's rivers. Elkin creek, which flows for the greater part of its course in Wilkes county, is used at Elkin for a woolen and a cotton factory (Elkin Manufacturing Company), with a fall of 22 feet, and using 70 horse-power during nine months and about 50 during the remaining time. Gwyn & Chatham have also a woolen-mill and a flour- and grist-mill at the same place, but from a different dam, the fall used being 15 feet; 35 horse-power is used in the flour-mill. Elkin creek is said to be a very good stream for power, there being numerous falls not used. Three miles above Gwyn & Chatham's factory is a site known as Carter's falls, said to be a very fine power, with a large fall in a short distance. The banks of these streams being generally tolerably high, dams can be built without doing much damage by overflow, so that almost the entire fall of the streams is said to be practically available for power, and there seems no doubt that a large amount of power could be utilized. It is to be added that this part of the state is remarkable for its healthy and salubrious climate. The principal drawback at present is its inaccessibility, the Elkin factory, for example, being 40 miles from the nearest railroad station. The other streams belonging to this class need not be referred to in detail, as I am able to present no particulars regarding them beyond what has already been given. They offer numerous sites for good small powers, but in all probability none of them would afford more than 2 or 3 horse-power per foot fall in dry seasons. Sites can be found on them, however, where falls of 20 or 30 feet can be obtained.

The following table will give in a more connected form a view of the drainage areas of the various streams tributary to the Yadkin and Great Pee Dee:

Drainage areas of the tributaries of the Yadkin and Great Pee Dee rivers.

Stream.	Tributary to what.	Place.	Drainage area.
			Sq. miles.
Waccamaw river	Great Pee Dee	Mouth	1,295
Do	do	In North Carolina	782
Do	do	In South Carolina	513
Black river	do	Mouth	1,510
Little Pee Dee river	do	do	3,022
Do	do	In South Carolina	1,080
Do	do	In North Carolina	1,942
Do	do	Mouth of Lumber river	415
Lumber river	Little Pee Dee	Mouth	1,790
Lynch's river	Great Pee Dee	do	1,358
Little Lynch's creek	Lynch's river	do	170
Black creek	Great Pee Dee	do	457
Jones' creek	do	do	96
Hitchcock's creek	do	do	102
Do	do	At mouth of Falling creek	86
Falling creek	Hitchcock's creek	Mouth	12
Little river	Great Pee Dee	do	400
Brown's creek	do	do	206
Uwharrie river	do	do	317
Rocky river	do	do	1,405
Do	do	At Garmen's mills	523
Long creek	Rocky river	Mouth	158
Richardson's creek	do	do	199
Lane's creek	do	do	140
Crane creek	Yadkin	do	103
Grant's creek	do	do	84
South Yadkin river	do	do	820
Do	do	Hairston's falls	591
Third creek	South Yadkin	Mouth	215
Fourth creek	Third creek	do	68
Bear creek	South Yadkin	do	40
Dutchman's creek	do	do	18
Hunting creek	do	do	146
Do	do	Factory	100
Rocky river	do	Mouth	94
Do	do	Factory	88

Drainage areas of the tributaries of the Yadkin and Great Pee Dee rivers—Continued.

Stream.	Tributary to what.	Place.	Drainage area.
Second creek	South Yadkin	Mouth	108
Muddy creek	Yadkin	...do	179
Abbott's creek	...do	...do	198
Dutchman's creek	...do	...do	97
Deep creek	...do	...do	106
Little Yadkin river	...do	...do	58
Ararat river	...do	...do	315
Do	...do	Mount Airy	60
Stewart's creek	Ararat	Mouth	51
Loving's creek	...do	...do	52
Elkin creek	Yadkin	...do	63
Fisher's river	...do	...do	90
Mitchell's river	...do	...do	81
Roaring river	...do	...do	89
Mulberry creek	...do	...do	56
Reddie's river	...do	...do	47
Cub creek	...do	...do	37
Moravian creek	...do	...do	31
Warrior creek	...do	...do	33
Buffalo creek	...do	...do	41

Table of power utilized on the Yadkin (Pee Dee) river.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total horse-power utilized.
						Feet.	
Pee Dee river	Atlantic ocean	North Carolina	Richmond	Flour and grist	1	6.5	8
Do	...do	...do	...do	Cotton-gin	1	6.5	4
Do	...do	...do	Anson	Flour and grist	2	......	24
Do	...do	...do	Montgomery	...do	4	......	49
Do	...do	...do	...do	Cotton factory	1	8.0	30
Yadkin river	...do	...do	...do	...do	1	......	30
Do	...do	...do	...do	Flour and grist	3	......	120
Do	...do	...do	...do	Saw	1	7.0	16
Do	...do	...do	Stanley	...do	1	7.5	12
Do	...do	...do	...do	Flour and grist	3	22.5	120
Do	...do	...do	Rowan	...do	3	14.0	84
Do	...do	...do	Davidson	...do	7	36.0	99
Do	...do	...do	...do	Saw	2	18.0	26
Do	...do	...do	Forsyth	Flour and grist	1	4.0	40
Do	...do	...do	Yadkin	...do	1	18.0	10
Do	...do	...do	...do	Saw	2	29.0	26
Do	...do	...do	Caldwell	Cotton factory	1	25.0	50
Waccamaw and tributaries	Great Pee Dee	South Carolina	Horry	Flour and grist	2	13.0	22
Do	...do	North Carolina	Brunswick	...do	1	9.5	6
Do	...do	...do	...do	Saw	1	9.0	12
Black river and tributaries	...do	South Carolina	Clarendon	Flour and grist	5	......	136
Do	...do	...do	Sumter	...do	8	67.0	96
Little Pee Dee river and tributaries	...do	...do	Marion	...do	12	81.5	128
Do	...do	...do	...do	Saw	4	28.5	60
Do	...do	...do	Marlborough	Flour and grist	5	35.0	65
Do	...do	North Carolina	Columbus	...do	3	23.5	20
Do	...do	...do	...do	Cotton-gin	3	24.0	......
Do	...do	...do	Robeson	Flour and grist	27	195.0	259
Do	...do	...do	...do	Saw	10	68.0	134
Do	...do	...do	Richmond	Cotton factory	1	8.5	44
Do	...do	...do	...do	Agricultural implements	1	5.0	6
Do	...do	...do	...do	Flour and grist	8	61.0	74
Do	...do	...do	...do	Saw	2	10.0	18
Lynch's river and tributaries	...do	South Carolina	Williamsburgh	Flour and grist	6	61.0	63
Do	...do	...do	Sumter	...do	3	20.0	19
Do	...do	...do	...do	Saw	2	......	31
Do	...do	...do	Darlington	Flour and grist	6	......	88
Do	...do	...do	...do	Rice	1	6.0	25

Table of power utilized on the Yadkin (Pee Dee) river—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total horse-power utilized.
						Feet.	
Lynch's river and tributaries	Great Pee Dee	South Carolina	Chesterfield	Flour and grist	2	27.0	70
Do	do	do	Kershaw	Saw	1	7.0	10
Do	do	do	Lancaster	do	1	12.0	20
Do	do	do	do	Flour and grist	4	52.0	46
Other tributaries of	do	do	Marion	do	4	......	53
Do	do	do	Darlington	Saw	2	......	34
Do	do	do	do	Flour and grist	11	......	200
Do	do	do	Marlborough	do	12	87.0	154
Do	do	do	do	Cotton-gin	2	12.0	16
Do	do	do	Chesterfield	Flour and grist	4	......	38
Do	do	do	do	Saw	3	25.0	62
Do	do	do	do	Tar and turpentine	1	......	40
Hitchcock's creek and tributaries	do	North Carolina	Richmond	Cotton factory	2	60.0	280
Do	do	do	do	Saw	1	10.0	40
Little river	do	do	Montgomery	do	2	27.0	42
Do	do	do	do	Flour and grist	7	77.0	127
Rocky river and tributaries	do	do	Anson	do	3	21.0	45
Do	do	do	do	Saw	2	14.0	22
Do	do	do	Stanley	Flour and grist	12	85.0	258
Do	do	do	do	Saw	4	28.0	80
Do	do	do	Marion	do	1	10.0	20
Do	do	do	do	Flour and grist	8	72.0	122
Do	do	do	Cabarrus	do	20	220.0	321
Do	do	do	do	Saw	3	......	60
Do	do	do	do	Cotton-gin	3	34.0	55
Do	do	do	Mecklenburg	Flour and grist	2	38.0	27
Do	do	do	Rowan	do	6	92.0	42
South Yadkin river and tributaries	Yadkin river	do	do	do	11	124.0	148
Do	do	do	Davie	do	8	101.0	171
Do	do	do	do	Saw	3	37.0	38
Do	do	do	Iredell	do	6	97.0	109
Do	do	do	do	Leather	1	15.0	10
Do	do	do	do	Cotton-gin	3	56.0	31
Do	do	do	do	Flour and grist	30	456.0	480
Do	do	do	do	Cotton factory	2	37.0	140
Do	do	do	Alexander	do	4	60.0	92
Do	do	do	do	Saw	1	12.0	15
Do	do	do	do	Furniture	1	7.0	10
Do	do	do	do	Blacksmithing	1	7.0	4
Other tributaries of	do	do	Richmond	Flour and grist	3	50.0	54
Do	do	do	do	Cotton-gin	1	10.0	20
Do	do	do	Montgomery	Flour and grist	9	......	92
Do	do	do	do	Saw	1	8.0	15
Do	do	do	Randolph	do	6	52.0	66
Do	do	do	do	Flour and grist	13	206.0	192
Do	do	do	Davidson	do	28	240.0	446
Do	do	do	do	Saw	12	80.0	154
Do	do	do	do	Cotton-gin	1	9.0	4
Do	do	do	Forsyth	Flour and grist	13	227.0	188
Do	do	do	Stokes	do	5	70.0	58
Do	do	do	do	Saw	3	......	73
Do	do	do	Anson	do	2	23.0	36
Do	do	do	do	Flour and grist	7	125.0	137
Do	do	do	Mecklenburg	do	2	38.0	27
Do	do	do	Rowan	do	13	......	132
Do	do	do	Davie	do	7	......	75
Do	do	do	do	Saw	1	9.0	8
Do	do	do	Yadkin	Flour and grist	12	......	171
Ararat and tributaries	do	do	Surry	Cotton and woolen factory	4	53.0	95
Do	do	do	do	Flour and grist	8	112.0	133
Do	do	do	do	Saw	5	69.0	96
Other tributaries of	do	do	do	do	4	53.0	37
Do	do	do	do	Flour and grist	11	163.0	110
Do	do	do	do	Cotton and wool	2	37.0	......
Do	do	do	Wilkes	Flour and grist	12	140.0	102
Do	do	do	do	Saw	2	12.0	14
Do	do	do	do	Woolen	1	......	......

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VII.—THE SANTEE RIVER AND TRIBUTARIES.

Drainage-basins of the Santee and Edisto rivers, South Carolina.

DRAINAGE AREAS.

	Square miles.
Santee river, at mouth	14,725
Congaree river, at mouth	7,965
Congaree creek, at mouth	115
Edisto river, at mouth	2,883
North fork Edisto river, at mouth	745
South fork Edisto river, at mouth	790
Shaw's creek, at mouth	119
Rocky creek, at mouth	195

THE SANTEE RIVER.

The Santee river is formed by the junction of the Congaree and the Wateree rivers at the angle of the four counties of Richland, Sumter, Orangeburgh, and Clarendon, South Carolina, whence it flows in a general direction nearly southeast between Clarendon, Williamsburgh, and Georgetown counties on its left, and Orangeburgh and Charleston on its right, emptying into the Atlantic ocean about 10 miles north of Cape Romain. Its total length, in a straight line, is about 90 miles, and by the river about 184 miles. There are no towns on the river, although it is navigable for its entire length, it being considered practicable to secure a depth of 7 feet at low water for 154 miles and 5 feet for the remaining distance. The river flows through a fertile country, cotton being the principal staple on the upper part and rice on the lower, and the banks, more or less subject to overflow, are lined with extensive forests and swamps. As the river lies entirely below the fall-line, and as its general character corresponds exactly with that of the Great Pee Dee below Cheraw, it need not be described further. The total area drained by the stream is about 14,700 square miles, and it has no tributaries of much importance below the junction of the Wateree and the Congaree. The width of the stream varies from 200 to 500 feet, and its fall averages about half a foot to the mile. The utilized power on its tributaries is tabulated herewith.

THE WATEREE (OR CATAWBA) RIVER.

The Catawba river rises on the eastern slope of the Blue Ridge, in McDowell county, North Carolina, its main source being between the Blue Ridge and a spur of the same known as Bald mountain. It first flows nearly northeast into Burke county, and then nearly east between Caldwell and Alexander on its left and Burke and Catawba counties on its right. It then bends quite abruptly toward the south, and flows in a direction a little east of south between Iredell and Mecklenburg counties, North Carolina, and Lancaster, Kershaw, and Sumter counties, South Carolina, on its left, and Catawba, Lincoln, and Gaston counties, North Carolina, and York, Chester, Fairfield, and Richland counties, South Carolina, on its right, uniting with the Congaree to form the Santee. It also flows for a short distance through Kershaw county, South Carolina. Its general course is seen to be nearly parallel to that of the Yadkin and the Great Pee Dee. The river is known as the Catawba down as far as the mouth of the Big Wateree creek, in Fairfield county, South Carolina, below which point it is known as the Wateree. Its total length, in a straight line, is about 160 or 170 miles, but by the general course of the river it is nearly 225 miles, and over 300 miles if all its windings are followed. The length of the Wateree is about 105 miles,* and the total length in South Carolina about 160 miles. The principal town on the river is Camden, South Carolina (population 1,780), there being no important ones above.

The stream is navigable as high as Camden, it being probably practicable to secure a depth of 2 feet and over up to this place. One light-draught steamer now plies upon the river. Above Camden the fall of the stream is so great that navigation is not practicable. About the year 1826 the state of South Carolina attempted to render the river navigable by means of locks, dams, and canals, and several very extensive and important works were constructed at great expense; but the undertaking is said to have been given up before the works were completed.

The total area drained by the stream embraces about 5,225 square miles (of which 3,085 are in North Carolina), and the drainage-basin resembles in many respects that of the Yadkin, so that it need not be described here in detail. Like the Yadkin, the upper part of the river flows between parallel ranges of mountains, from which it receives a number of tributaries, affording considerable water-power, and with a rapid fall, the width of the valley being about the same as that of the Yadkin. In the lower half of its course in North Carolina the valley of the Catawba is very narrow—not over 15 or 20 miles in width—and it receives only one important tributary, the South fork, which enters from the west near the South Carolina line, after draining an area of about 730 square miles. Below this point the valley is wider, but there are no tributaries of much importance. A few miles above Camden the river crosses the fall-line, and below that point it partakes of the general character of the streams of the eastern

* Annual Report Chief of Engineers, 1880, p. 915.

RICHLAND
SUMTER
LEXINGTON
COLUMBIA
Saluda Riv.
Broad Riv.
Wateree Riv.
C.C.&A.R.R.
Congaree Cr.
Congaree Riv.
CLARENDON
WILLIAMSBURG
GEORGETOWN
Rock Cr.
Shaws Cr.
North Fork Edisto Riv.
South Fork Edisto Riv.
ORANGEBURGH
S.C.R.R.
SANTEE
RIVER
N.W.R.R.
CHARLESTON
Edisto
River
Big Salkehatchee Riv.
COLLETON
CHARLESTON & SAVANNAH R.R.
N
S
W
E
Scale:
10
20
30
40
50 M.

division. The country drained by the river is very fertile and well populated, the productions being about the same as in the Yadkin valley. The valley abounds in building-stone of the best kind, and in Gaston, Lincoln, and Catawba counties there are fine deposits of iron ore.

As regards bed, banks, freshets, and bottoms, the river resembles the Yadkin, except that the bottoms are narrower in the lower half of its course in North Carolina. There are no lakes in the basin, but in the upper part the facilities for storage are said to be good.

The average rainfall in the basin is about 50 inches, of which about 12 fall in spring, 14 in summer, 10 in autumn, and 14 in winter. Toward the upper part of the stream, however, the rainfall in winter increases, and is probably greater than in the summer.

The elevation of the stream at different points is given in the following table, from which it will be seen that the fall is very great for such a large stream; and it is this large fall which has prevented the river from having ever been made navigable, although, as already remarked, many years ago the state of South Carolina expended a great amount of money endeavoring to make it navigable by means of locks, dams, and canals:

*Table of declivity of the Catawba and Wateree rivers.**

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Junction with Congaree	0	80±			
			125	285	2.28
Crossing of Chester and Cheraw railroad	125	365			
			25	131	5.24
Crossing of Charlotte, Columbia, and Augusta railroad	150	496			
			20	104	5.20
Crossing of Charlotte and Atlanta Air-line railroad	170	600			
			55	210	3.82
Crossing of Western railroad of North Carolina	225	810			
			25	168	6.70 (?)
Five miles northwest of Hickory	250	978			
			18	41	2.28 (?)
Morganton	268	1,019			
			50	491	9.80
Mill creek at Old Fort	318	1,510			
			8+	540	67.50
Mill creek, last crossing of Western railroad of North Carolina	326±	2,050			
			8+	608	76.00
Swannanoa gap (headwaters)	334±	2,658			

* From some discrepancies in the data obtained from various sources I am inclined to believe that some of these elevations are those of the rails, and not of the water surface. On this account this table must be considered as only a rough approximation.

The flow of the river was measured by Professor Kerr near Hickory, giving 2,156 cubic feet per second, which is evidently not the low-season flow, as the drainage area above this point is not much over 1,000 square miles.

The map shows the railroads which cross the stream, from which it will be seen that it is easily accessible in almost all of its parts.

I proceed to describe the powers in detail, ascending the river.

Formerly the head of navigation was 5 miles above Camden, at which point the river crosses the fall-line in a long shoal extending through several miles. When the river was made navigable by the state, in 1826 or thereabout, this fall was overcome by a canal 5 miles in length, with 6 locks, aggregating 52 feet fall,* the position of the canal being shown on the map. I visited the place from Camden, from which town it is distant by road about 12 miles, for the purpose of ascertaining the availability of the power. The canal is on the west side of the river, which it leaves just below a rocky bluff, from which a dam extended out into the river. This old dam is entirely gone, and I could not ascertain what its height had been; but the fall for the next mile above is probably 10 or 12 feet, according to the pocket-level, although the stream is not rocky except for a few hundred feet. The canal had a guard-lock about a quarter of a mile from its head, and below that it passes through nearly level or gently rolling bottom-lands, and is now entirely overgrown with underbrush and filled up with deposits of all kinds, so that it is in some places scarcely distinguishable. It retreats some distance from the river, the bottom between them being on the average several hundred yards wide, and parts of it are subject to overflow in times of high water. Near the foot of the canal is a flight of three locks, and a little farther down the canal passes out into Sawney's creek by an outlet-lock. I was unable to find the sixth lock mentioned by Mills. The principal part of the fall in the river occurs near the lower end, or about two-thirds of the distance from the head, and is utilized for a small grist-mill, with two pair of stones, by means of a rough wing-dam and a race a quarter of a mile long, affording a fall of 6 or 7 feet and a fall to the tail-race sufficient to avoid the trouble occasioned by ordinary rises of the water. In a distance of rather over a mile, from a little above the head of the race leading to the grist-mill, the fall, as ascertained by the pocket-level, is in the neighborhood of 20 feet. Above this the bottom bordering the river is subject to overflow to a considerable extent, while below it is only occasionally flooded. Below the mill, too, the bottom becomes narrower, and is more undulating than above. As regards the most advantageous method of utilizing the power, my examination was too superficial to permit of any definite conclusions being reached. To clear the old canal out would require considerable work, although of an easy kind. The capacity of the canal, too, could be easily enlarged if it were considered desirable to utilize the entire power, which might be done by locating

* Statistics of South Carolina, including a view of its natural, civil, and military history, general and particular. By Robert Mills (1826).

the mills at the lower flight of locks, where, if we accept Mills' statement, a fall of some 50 feet could be obtained; and the location here is probably as safe and as favorable as anywhere along the canal. A smaller power could be much more easily secured probably by building a dam somewhere near the head of the grist-mill race (whether the bed and banks there would be found very favorable I cannot say) and leading a canal down near to the old locks, in which way a fall of 20 feet might probably be secured, the race being a mile or so long. As regards the amount of power available, I have tabulated it below, basing it, like all my others, on estimates, in the entire absence of any data regarding the flow:

Table of power at "Wateree canal".

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	Horse-power available, gross.
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*52 feet fall.*
Minimum	4,376	*52	963	109.4	5,700
Minimum low season			1,320	150.0	7,750
Maximum, with storage			3,500	398.0	20,700
Low season, dry years			1,500	170.5	8,850

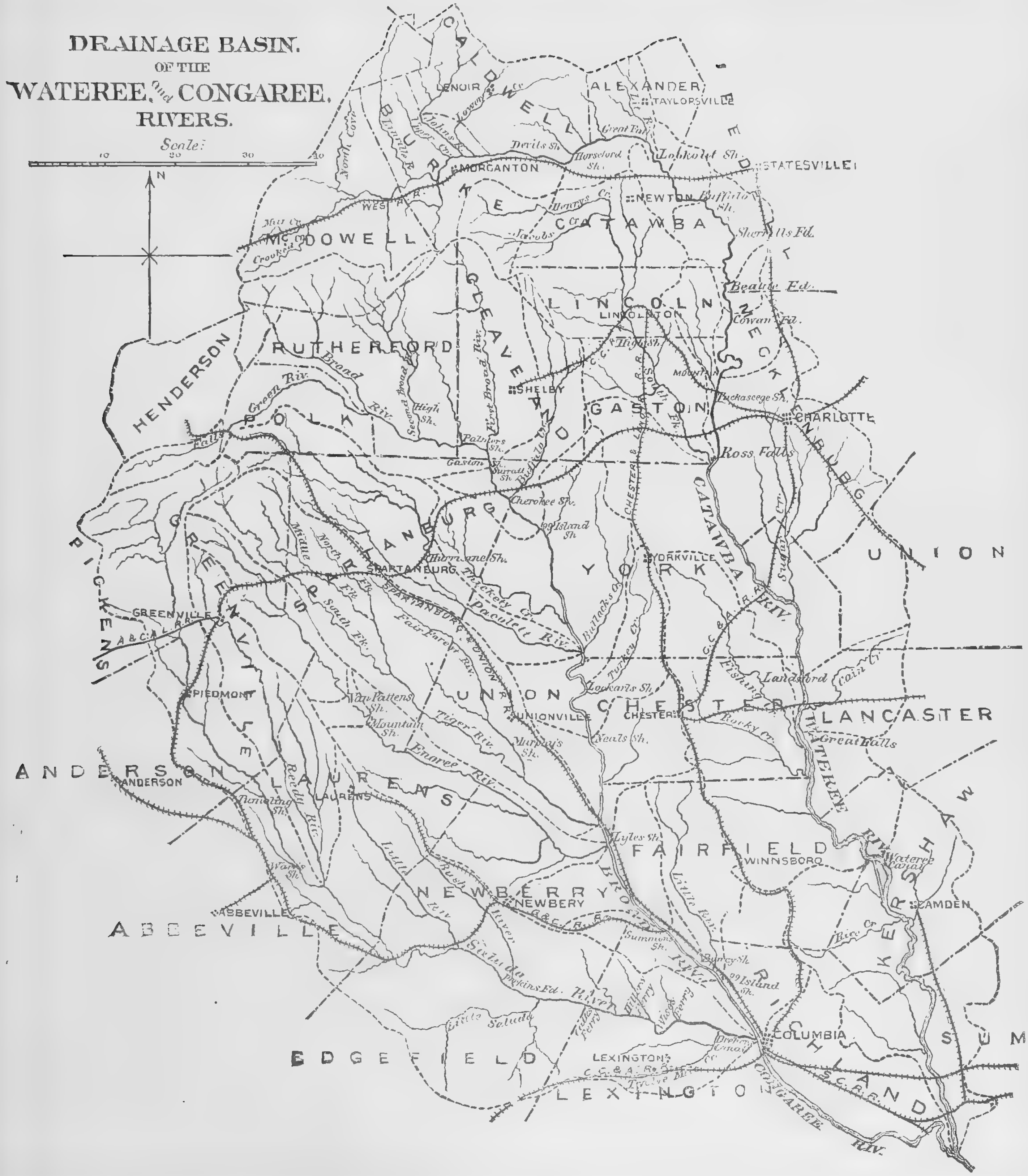
*Mills.

I did not have time to look at the other side of the river, and only cursorily at the west side; but as the canal was built on the west side, it may be presumed that the "lay of the land" there is more favorable for canals and buildings than the other. The fall in the river is not accompanied by any violent commotion, being gradual, and the river wide, with a large volume of water. This power is the first of the four great powers on the Catawba (Wateree) river.

The second of these powers, and the next one above the Wateree canal which necessitated any extensive navigation works, is at the great falls of the Catawba, near Rocky Mount. Between the two places, however, there is a very considerable fall, it being stated by Mr. Wolbrect, United States assistant engineer, that the fall in the upper 17 miles of the Wateree river is 75 feet, or 4.5 feet to the mile.* Nevertheless, no particular water-powers between the two referred to were brought to my notice, although I obtained information of a few small grist-mills.

The fall at the Great falls is similar in some respects to that on the Yadkin at the "narrows", described on page 80. The navigation works planned were very extensive. In ascending the river the course of the canal is as follows: Leaving the river about opposite Rocky Mount, on the west side, it rises to the level of the bottom (which borders the river at this place) by a flight of two locks, aggregating about 18 feet lift, crosses the bottom, and after passing around a steep and rocky bluff, at which place it was necessary to build the outer wall of the canal of solid masonry for a distance of half a mile or thereabout, within which distance occurs one intermediate lock, with a lift of about 9 feet, it debouches into Rocky creek, a small stream which flows into the Catawba at a point in the neighborhood of a half or a quarter of a mile above its mouth, opening into it by a guard-lock, with a lift of about 8 feet, situated at one end of a wooden dam, which extended across the creek, backing up the water, with a navigable depth, to a distance of about a mile. This first canal is about a mile in length, and has a total rise, according to what has been said, of about 35 feet from low water in the Catawba at the outlet-lock to the crest of the dam across Rocky creek. Between the canal and the river is a bottom, in which the lower part of the canal itself lies, and which is subject to overflow in times of freshet. It was probably on this account that the canal was carried so closely around the bluff. In fact, this part of the river, just below the principal fall, is subject to large rises, much larger than within the next few miles above, where the declivity is great, and down which the water rushes so rapidly that the smaller declivity below is insufficient to carry it off without a considerable rise. This part of the canal, as well as that above, is so overgrown with brush and by trees of half a century's growth that its original dimensions cannot be accurately determined. The lock-chambers are about 70 feet by 10 feet, and the canal was perhaps 20 or 25 feet wide at the top and 3 or 4 feet deep. The dam across Rocky creek was probably about 12 or 13 feet high, and its pool, as before mentioned, was navigable for about a mile, at which point the second portion of the canal commenced, leaving the river by a flight of 4 locks, with together 32 feet lift, by which it rises to the level of a narrow valley running about parallel with the Catawba, but separated from it by a ridge. Along the side of this valley, out of sight of the Catawba, although the latter is only a quarter of a mile distant, and with a ridge nearly a hundred feet high between them, passes the canal for a distance of about 2 miles, at the end of which the valley that it has been following opens out into the river, but at an elevation above it of 20 or 30 feet, having gradually become narrower as the river was approached, and at its upper end being very little more than wide enough to carry the canal without cutting into the hill-sides. Within this two miles, from the point where it leaves Rocky creek till it again reaches the river, the canal has, in addition to the 4 locks already mentioned, two flights of locks, one with 4 locks, aggregating 36 feet lift, and another with 3 locks, and in all 27 feet lift, as far as could be ascertained. Both of these flights of locks are situated in the lower part of the valley followed by the canal, and at points where it is several hundred yards wide. The ridge between the river and the canal is interrupted at a point about a quarter of a mile below where the canal again comes in sight of the river by a narrow ravine, which retreats down to the river, and is not over 100 feet wide. From the point where the canal reaches the bank of the river it proceeds about a mile further, first skirting the face of a steep and rocky bluff, and

*Annual Report Chief of Engineers, 1880, p. 915.



DRAINAGE BASIN.
OF THE
WATEREE, and CONGAREE,
RIVERS.
Scale:
10
20
30
40
N
CALDWELL
LENOIR
ALEXANDER
TAYLORSVILLE
BURKE
MORGANTON
STATESVILLE
IREDELL
NEWTON
CATAWBA
McDOWELL
LINCOLN
LINCOLNTON
HENDERSON
RUTHERFORD
CLEAVELAND
SHELBY
GASTON
CHARLOTTE
MECKLENBURG
POLK
SPARTANBURG
SPARTANBURG
YORK
YORKVILLE
UNION
PICKENS
GREENVILLE
GREENVILLE
PIEDMONT
UNION
UNIONVILLE
CHESTER
CHESTER
LANCASTER
ANDERSON
ANDERSON
LAURENS
LAURENS
FAIRFIELD
WINNSBORO
KERSHAW
CAMDEN
ABBEVILLE
ABBEVILLE
NEWBERRY
NEWBERRY
RICHLAND
COLUMBIA
EDGEFIELD
LEXINGTON
LEXINGTON
SUM
Broad Riv.
Green Riv.
Catawba Riv.
Wateree Riv.
Enoree Riv.
Tiger Riv.
Pacolet Riv.
Saluda River
Congaree Riv.
Ross Falls
Great Falls
Wateree Canal

then across a bottom, and after rising about 9 feet, by a lock situated in the latter, it opens into the river by a guard-lock and a dam, which seems to have extended across to an island, backing up the water between it and the right bank of the river, as well as some distance up Fishing creek, which enters a short distance above, and enabling boats to pass out into the river, up between the island and the shore, and up Fishing creek, just as they did below up Rocky creek. The third portion of the canal, which I did not have an opportunity to examine, leaves Fishing creek at a point a mile or so from its mouth (according to the map), and after a length of a mile or a mile and a half, in which distance, according to Mills, the fall is 56 feet, opens into the river again, which is navigable from this point to Landsford, a distance of 12 miles or thereabout. As regards the river itself, its fall in a distance of a mile and a half or thereabout, down to the point where the second portion of the canal passes in behind the ridge, as ascertained by the pocket-level, is about 35 or 40 feet. At this point there was formerly a small mill. Below this the river is narrower, and the water rushes with great velocity between steep, rocky, and almost vertical banks, falling about 25 feet in less than a quarter of a mile, down to the mouth of the ravine already referred to as running up to the canal, making a total fall to this place from a point not far from the head of the second portion of the canal of, say, 60 feet in a distance of about one and a half miles. Just below the ravine was located a cotton factory, using a fall of some 5 to 7 feet, with a wing-dam, and built almost over the water. The banks in this portion of the river are so steep and rocky as to preclude the construction of a canal or of extensive buildings, at least on the west side of the river. The cotton factory was a small building, not more than 50 by 25 feet. From the mouth of the ravine the river falls about 30 feet in the next quarter of a mile, making nearly 100 feet in about 2 miles. These are the great falls of the Catawba. The total fall is stated to be 173 feet in 8 miles.* The largest fall in a short distance occurs between the old mill-site and the ravine, the river at this point being not over 150 feet wide, while its average width for half a mile is not over 200 feet perhaps, and at the narrowest part it rushes with tremendous force over its rocky bed—a sheet of foam, falling some 10 or 15 feet in 150 or 200 feet.

The enormous power at this place is entirely unutilized at present, but a considerable portion of it could be rendered available without much difficulty, I think, in various ways. I have already mentioned the fact that except for small falls and small buildings there is no opportunity for the utilization of power along that part of the river opposite the second portion of the canal. A building might be erected on the site of the old factory and a fall of 10 feet obtained with ease, but only room for a small building. It may be mentioned that the dwellings of the factory operatives were on the top of the ridge between the river and the canal. But any scheme for the extensive utilization of the power must, I think, include the use of the old canal, and in this respect various methods may be employed, as follows:

1st. By rebuilding the dam at the head of the second portion of the canal, raising that portion of the canal below the first lock and locating the mills in or near the ravine already described, discharging the water through the same into the river, a fall of at least 50 feet could be obtained, necessitating, however, considerable work in cutting out the ravine for a tail-race, and with poor building facilities. The quantity of water will vary, of course, according to the dimensions given to the canal. If the canal is not raised to the level of the former dam, or nearly so, but is left at the ravine, as it was originally, the fall available will be at least 30 or 35 feet.

2d. At any or all of the three flights of locks mentioned above Rocky creek the facilities for utilizing a large power are very good, there being ample building-room, and the water being discharged into Rocky creek. This is, in my opinion, the best way of utilizing the power. The available fall of all three flights is 95 feet, and the fall of Rocky creek would doubtless prevent any danger whatever from freshets or any trouble from backwater; of course there would be no trouble with ice. If the level of the canal were raised, so that it ran (nearly) level from its head to these flights of locks, the available fall would be increased to about 110 feet.

3d. As regards the power on the first (lowest) portion of the canal, below Rocky creek, the total amount of water brought through the second portion, together with the entire flow of Rocky creek, could be turned into the canal, provided it were of sufficient capacity and utilized lower on the stream. By raising that portion of the canal below the first lock, an available fall of about 30 or 35 feet could be secured at the lower end; but as this whole bottom, through which the canal passes, is subject to overflow, the facilities for building are not so good as in the last case. Still, there is no reason why this fall could not be utilized, if desired. This site would suffer also more trouble with backwater than the last one described, which would be, in fact, almost absolutely free from it. Summing up the lifts of all the locks in the first and second portions of the canal we see that the total fall is 130 feet and over, as follows:

	Feet.
One guard-lock at upper end of second portion, lift, say	—
One lock half a mile below, lift, say	9
Flight of 3 locks, 9 feet each, behind ridge, lift, say	27
Flight of 4 locks, 9 feet each, behind ridge, lift, say	36
Flight of 4 locks, 8 feet each, behind ridge, lift, say	32
Guard-lock at head of first portion (lowest), lift, say	—
Lock, half a mile below, close to bluff, lift, say	9
Two locks, outlet to river, 9 feet each, lift, say	18
Total	131+

* Mills' statistics of South Carolina.

Mills states the fall as 121 feet, and the number of locks as 13; but as this part of the canal was in process of construction when his book was written, some changes were evidently made thereafter.

The accompanying sketch of the Catawba river at the Great falls, South Carolina, while it makes no pretensions to accuracy, will at least give some idea of the general situation.

The upper portion of the canal, from Fishing creek through to the river, I was unfortunately unable to examine. The power there is said to be available, and any persons seeking a location will, of course, thoroughly examine this as well as the lower portion of the canal.

As regards the amount of power available, I have estimated it as follows:

Table of available power at the great falls of the Catawba.

State of flow (see pp. 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	Horse-power available, gross.	Remarks.
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*173 feet fall.*	
Minimum	*3,600	173	793	90	15,500	Drainage area for second portion of canal is 3,830, and for lower portion 4,015 square miles, taking in Fishing and Rocky creeks.
Minimum low season			1,080	123	21,000	
Maximum, with storage			2,900	330	57,000	
Low season, dry years			1,230	140	24,000	

*Without Fishing creek.

To render the whole of this flow available would require a canal of considerably larger dimensions than the existing one, as will be seen by reference to the table of capacity calculated for the canals at Weldon, on the Roanoke, and Buckhorn falls, on the Cape Fear.

The power just described is about 25 miles from Chester, the nearest point on the Charlotte, Columbia, and Augusta railroad, and about 8 miles below where the Chester and Cheraw railroad crosses the river. The upper portion of the canal, above Fishing creek, is not more than five or six miles from the latter road, so that it has the advantage in point of location, and should by no means be overlooked by persons wishing to find power.

Proceeding up the river, there is no power of much importance till we arrive at Landsford, about 4 miles above the railroad, where the third canal was built by the state. This canal was nearly 2 miles long, and had a guard-lock and 4 lift-locks, with about 35 feet lift in all. It passes through a bottom for its entire length, retreating in some places about 300 yards from the river, leaving abundant room for building purposes, and is not liable to be often overflowed. At the head of the canal a curved dam of loose rock extends across to an island, its length being about 1,500 feet, and its height 4½ feet. It raises the water only about 2½ feet. About a mile below is a pair of locks with a lift together of 18 feet, over which Mr. W. R. Davie has a grist-mill, using a fall of 18 feet, with a turbine-wheel giving 25 horse-power, discharging the water into the river through a break in the bank of the canal below the locks, and having a fall of 6 or 7 feet to the tail-race. The total fall from the ordinary level of water in the canal to low water in the river at this place is nearly 29 feet. The mill is not often troubled by high water, owing to the rapid fall in the river for some distance below. Five hundred yards or over below this mill are two outlet-locks, with a total lift of about 17 feet from low water, and making the total fall in the canal, exclusive of that in the guard-lock, about 35 feet. With a tight dam at the head of the canal a fall of 40 feet could be obtained, which, however, could not all be utilized, except perhaps at low water, unless the dam were made over 6 or 8 feet high. The stream is quite wide opposite the canal, and the rise in freshets not great.

The drainage area above Landsford is about 3,425 square miles. The available power I estimate as follows:

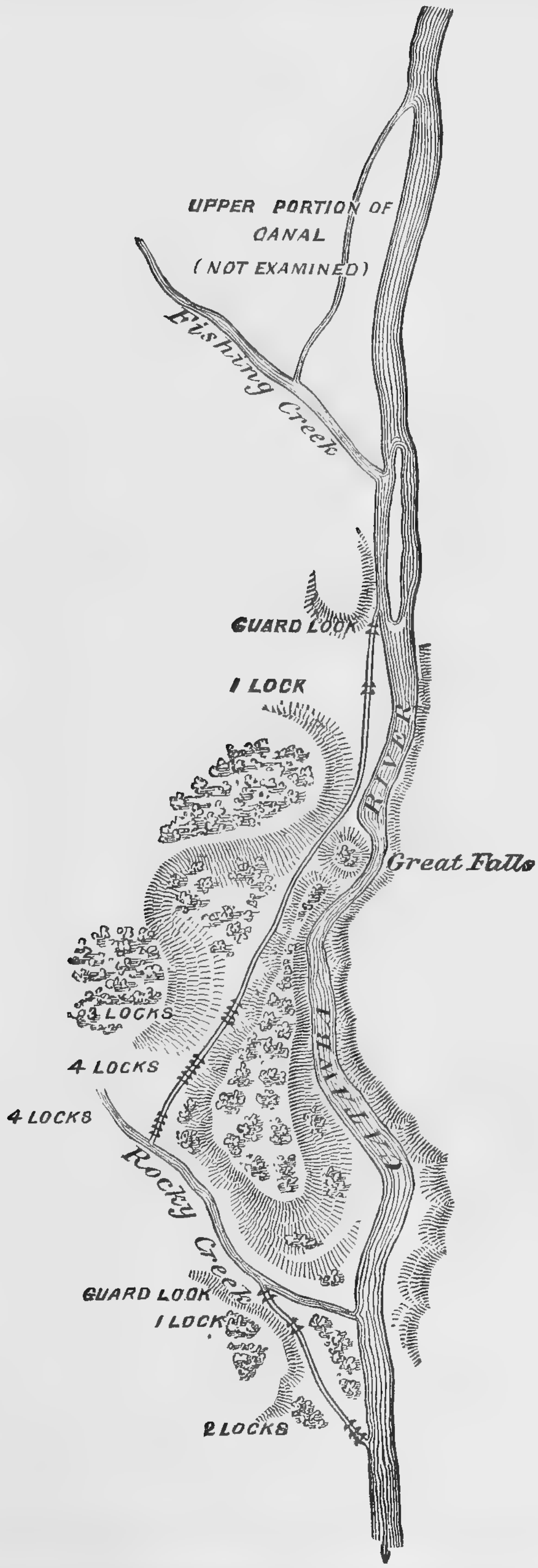
Table of power at Landsford.

State of flow (see pp. 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.			Remarks.
	Square miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*18 feet fall.*	*40 feet fall.*	
Minimum	3,425	40	750	85.3	1,540	3,400	25 horse-power (net) utilized.
Minimum low season			1,027	116.7	2,100	4,650	
Maximum, with storage			2,900	330.0	5,900	13,000	
Low season, dry years			1,160	131.8	2,370	5,270	

This site is within 4 miles of the Chester and Cheraw railroad, from which a branch road can be easily extended to it.* It is 22 miles from Chester, and about 20 miles below the crossing of the Charlotte, Columbia, and Augusta railroad. It will be found, I think, to be the most available site which we have thus far met upon the river, although I cannot speak of the upper part of the canal below, near Fishing creek, not having visited it. Opposite the canal, on the east side of the river, is a small grist-mill, with a wing-dam and a small fall.

Above Landsford there are no powers of importance in South Carolina, although there is a small mill just below where the Charlotte, Columbia, and Augusta railroad crosses. There are several shoals, with falls of from 3 to 5 feet, some of which have been used, but the trouble with high water is so great that they are of no value. A mile or so above the mouth of the South fork there was a grist-mill with a fall of 3 or 4 feet, and above it

* Liberal propositions are made for the development of this power with an 8-foot dam at the head of the canal.


UPPER PORTION OF
CANAL
(NOT EXAMINED)
Fishing Creek
GUARD LOCK
1 LOCK
RIVER
Great Falls
3 LOCKS
4 LOCKS
4 LOCKS
Rocky Creek
GUARD LOCK
1 LOCK
2 LOCKS

the cotton factory of the Rock Island Manufacturing Company, which was moved because the high water was so troublesome, the fall having been 5 feet. Both of them were on the Mecklenburg side.

It may be mentioned here that the width of the Catawba between the North Carolina line and the mouth of the Wateree creek varies between 300 and 3,000 feet, while the banks vary in height from 10 to 100 feet.

The river was surveyed in 1824, under authority of the state of North Carolina, between the state-line and Moore's shoals, 10 miles below Morganton, by Mr. Hamilton Fulton, a portion of whose map and profile is in the office of the state geologist in Raleigh, from which the table of shoals further on is condensed.* Beside the shoals mentioned in the table, there are numerous others of smaller fall, but which, however, may be more favorable for power than those named, being perhaps more favorably located, and permitting the erection of high dams. All these points can only be determined by a survey.

After Ross's falls, which is probably one of the shoals referred to as having been used by a small mill, or perhaps a factory, the next important shoal is Tuckasegee shoal (also called Powder-Mill shoal), close to the crossing of the Carolina Central railroad. It is only utilized on the west side by a grist-mill, with about 4 feet fall.

Three miles above it is the fourth large power on the Catawba, at Mountain Island shoal, about 3 miles above the railroad, and above the mouth of Dutchman's creek. The fall in the river between a point one mile above the factory, or a little above the head of the shoal, and the railroad bridge below is 38 feet,† but of this fall nearly 30 feet occurs in one mile near the factory. The bed of the stream is rock, the banks on the east side very bluffy, while they are shelving on the west and very favorable for building, with no danger in high water. The power is utilized to a small extent by the cotton factory of G. K. Tate & Brothers. At the head of the shoal is a series of three small islands near the right bank, with a distance of only a few feet between them and the shore, and between the islands and the shore a certain amount of water flows naturally, with no dam to turn it in. This water is all that is used by the factory, there being no dam at the head of the islands, and the only dams being three slough-dams, connecting the islands with each other and the lowest one with the shore, the two former of which are of rough stone and the third of crib-work, and about 40 feet long and 8 feet high. From the foot of the lowest island an artificial race about 600 feet long leads to the factory, where a fall of 22 feet is used and about 190 horse-power; in addition to which there is a grist- and saw-mill and a cotton-gin, using together 50 to 60 horse-power and 15 to 16 feet fall. Full capacity can be secured all the time. The total distance between the head of the small islands referred to and the factory is about three-quarters of a mile, below which the fall continues for a short distance. The fall in the canal is considerable, and I think that the total fall down to the factory is in the neighborhood of 26 feet.

The drainage area above this shoal being about 1,538 square miles, I have estimated the power as follows:

Table of power at Mountain Island shoal.

State of flow (see pp. 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*25 feet fall.*	*30 feet fall.*
Minimum	1,538	*30	300	34.1	850	1,000
Minimum low season			380	43.2	1,080	1,300
Maximum, with storage			1,350	153.4	3,800	4,600
Low season, dry years			450	51.1	1,275	1,500

* See description.

The whole of this large power is easily available on the west bank, with good facilities for buildings and canals. A series of mills could be built, using an average fall of 25 feet or more, and with little trouble from high water, and none from ice. The west side is not so favorable. It is to be remarked that the pond would probably be small, and the power could not be concentrated into fewer than 24 hours except by reservoirs elsewhere. The shoal is 12 miles from Charlotte and 3 miles from the Carolina Central railroad, with which it might easily be put in communication by rail. It is in the cotton-belt, and in a most healthy part of the country. It is one of the most available powers I visited.

Just above Mountain island the river makes a remarkable bend, or horse-shoe, the distance by land across the chord being 1½ miles, while it is 7½ miles around by the river.‡ This bend has been talked of as a site for water-power, which would afford a large fall if the bend were cut through. According to Professor Kerr, however, the river is sluggish along the bend, and the total fall is small, some 9 or 10 feet only.

I did not visit any of the shoals above Mountain island, and can therefore give no particulars regarding them beyond what is in the table. The next utilized power, however, if we pass over a few small saw- and grist-mills, is in Catawba county, where there are two cotton factories, located between Buffalo shoals and Lookout shoals, and within a few miles of the railroad. The Granite shoals mill, or the factory of the Catawba Manufacturing Company (A. M. Powell, president), uses a fall of 5½ feet and 35 or 40 horse-power. The dam is of wood and stone, built in 1871, costing $1,000, and the main part of it extends across to an island, being 200 feet long and 5.5 feet high, while a wing-dam 700 feet long and 2 feet high extends from the island, reaching only about half way across the river. There is no race. Full capacity can be secured all the time (except during high water). The other factory, Long

* Extract from Annual Report Chief of Engineers, 1876, p. 33, *et seq.* † From information furnished by B. S. Guion, C. E., Lincolnton, N. C.

‡ Annual report Chief of Engineers, 1876, app. G, p. 31.

Island factory, owned by Powell & Shuford, uses 7 feet fall and 35 or 40 horse-power, which can be obtained at all times. The dam extends half way across the river, was built in 1872, cost $3,000, and is of wood and stone, 500 feet long and 4 feet high. The race is 200 feet long.

The next improved power of importance is the mill of Ramsour, Bonnewell & Co., in Caldwell county, three miles from Hickory, but on just what shoal I do not know, although the location corresponds very well with that of Horseford shoals, the largest shoal on this part of the river. They have a dam made of logs, built in 1853, extending nearly half way across the river, being about 250 feet long and 18 inches high. A race one-half mile long leads to the mills (grist and saw), where the fall is 8 feet. Not over 40 or 50 horse-power is used, which can be obtained all the time. If this power is really at Horseford shoals, it is a valuable one, as the estimate of power shows.

Devil's shoals is said to be a very fine site, situated 6 miles from Hickory (on the Carolina Central railroad) and 12 miles south of Lenoir. It is not improved at all. A ledge of rock is said to extend entirely across the river, offering a fine site for a dam.

Above this I have no detailed information of the shoals, but there are doubtless other sites for power. The stream is rapid, the bed rock, and the low grounds on either side subject to overflow. The only mills in this part of the state are saw- and grist-mills. Near Morganton, at Rocky ford, Major J. W. Wilson has a good site, used for a grist-mill, the fall being 9 feet and over, with a dam 2 feet high, 400 feet long, and a head-race of 1,400 feet. The wheel gives 60 or 70 horse-power, and there is never lack of water.

Above Morganton the river has a rapid fall, but it is more gradual than below, the shoals being more numerous, but not with such great descents. Between Morganton and the mouth of Mill creek there are 197 shoals, with an average fall of about 2 feet, the distance being 50 miles. The valley narrows to two, one, and one-half miles in width.

In McDowell county the river forks into Mill creek, which the Western North Carolina railroad follows, and the South Catawba, on which occur the Catawba falls, where the fall is said to be several hundred feet in a short distance, but the stream is too small to be used much for power. Both of these streams, as well as the others which enter the Catawba in McDowell county, are mountain streams, with a large fall and often abrupt descents of many feet, forming cascades and cataracts of great beauty. Some of them are used by small grist- and saw-mills.

Summary of power on the Catawba and Wateree rivers.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Miles.*						*Feet.*		
Wateree canal	85±	4,375	12	14	10	14	50	52.00	5.00	5,700	7,750	20,700	8,850	25	7.0	0.8	
Great falls	117±	3,600+	12	14	10	14	50	173.00	8.00	15,500	21,000	57,000	24,000	0	0.0	0.0	
Landsford shoals	130	3,425	12	14	10	14	50	40.00	2.00	3,400	4,650	13,000	5,270	25	18.0	1.2+	
Ross' falls	161	1,725	12	14	10	14	50	8.13	0.90	300	400	1,400	450	.....	.....	.....	
Tuckasegee shoals	169	1,670	12	14	10	14	50	11.22	1.02	425	525	1,900	600	.....	.....	.....	
Mountain Island shoals	175±	1,538	12	14	10	14	50	46.52	3.10	1,600	2,000	7,000	2,300	250	22.0	30.0—	
Abernathy's falls	178	1,500±	12	14	10	14	50	3.93	0.22	130	170	600	200	.....	.....	.....	
Cowan's ford shoals	188	1,455	12	14	10	14	50	27.25	4.17	900	1,125	4,000	1,300	.....	....	.....	
Beattie's ford shoals	194	1,420	12	14	10	14	50	13.00	2.38	420	520	1,850	600	.....	.....	.....	
Sherrill's ford shoals	210	1,342	12	14	10	14	50	13.13	1.88	400	500	1,750	600	.....	.....	.....	
Crawford Island shoals	212	1,307	12	14	10	14	50	23.44	1.69	700	870	3,000	1,000	.....	.....	.....	
Small shoals	214	1,290	12	14	10	14	50	3.93	0.05	120	150	500	175	.....	.....	.....	
Buffalo shoals	215	1,287	12	14	10	14	50	11.41	0.66	325	400	1,450	475	.....	.....	.....	
	222	1,205	12	14	10	14	50	9.71	2.18	250	325	1,200	375	.....	.....	.....	Utilized, 80 horse-power and 12.5 feet fall.
	224	1,200	12	14	10	14	50	8.64	1.32	225	300	1,000	350	.....	.....	.....	
Lookout shoals	225	1,184	12	14	10	14	50	54.25	3.20	1,450	1,850	6,400	2,100	.....	.....	.....	
Lower Little river shoals	231	1,180	12	14	10	14	50	9.70	1.16	260	325	1,150	375	.....	.....	.....	
Canoe landing shoals	233	1,125	12	14	10	14	50	8.94	1.87	225	280	1,000	325	.....	.....	.....	
Great falls	235	1,100±	12	14	10	14	50	14.82	1.02	375	475	1,650	525	.....	.....	.....	
Horseford shoals	245	964	12	14	10	14	50	31.43	2.91	700	875	3,000	1,000	.....	.....	.....	
Shoal	249	935	12	14	10	14	50	8.88	1.82	190	240	850	275	.....	.....	.....	
Devil's shoals	251	918	12	14	10	14	50	13.78	1.01	290	360	1,275	425	.....	.....	.....	
Rocky ford shoals	262	557	12	14	10	14	50	9.50	0.30	100	140	575	160	.....	9.5	.....	
Between head of Wateree canal	90	4,376															
and crossing of Chester and Cheraw railroad.	125	3,450	12	14	10	14	50	200±	35.00	19,500	24,000	70,000	28,000	.....	.....	.....	
Between crossing of Chester and Cheraw railroad—	125	3,450															
and crossing of Western North Carolina railroad.	225	1,200	12	14	10	14	50	445	100.00	22,500	28,000	90,000	32,500	.....	.....	.....	These figures are of no practical value.
Between crossing of Western North Carolina railroad—	225	1,200	12	14	10	14	50	209	37.00	4,000	5,200	18,500	6,000	.....	.....	.....	
and Morganton	262	557															
Total between Camden	75	4,500	12	14	10	14	50	854±	187.00	52,000	65,000	199.000	75,000	607	257.5	2.0—	
and Morganton	262	557															

* See pages 18 to 21.

TRIBUTARIES OF THE CATAWBA (WATEREE) RIVER.

The point where the Wateree and the Congaree meet is nearly on the lower limit of the belt of sand-hills already referred to, perhaps a little below it. As a consequence, the tributaries of the Wateree for a distance of upward of 30 miles in a straight line belong to the class of sand-hill streams. Regarding them but little is to be said, none of them having been utilized except to a small extent. Some of them are swampy and of no value, while others might be made to afford large powers. The most prominent of these streams are Big and Little Pine Tree creeks, the latter a tributary of the former, which passes close by the town of Camden; and they are said to be the best of the sand-hill tributaries of the Wateree. The water-bearing stratum of the sand-hill streams in this neighborhood is stated to be an impervious white clay, while nearer the surface of the ground is a layer of pervious red clay. The valleys of the two streams above referred to are said to be very favorable to the production of large ponds, so that by damming large storage-room can be obtained. They are utilized by saw- and grist-mills, and offer some available sites for power, regarding which I gained the following information: Big Pine Tree creek has five sites, of which all have at some time been improved. The lowest mill, a grist-mill and cotton-gin, uses only a part of the creek, and is subject to stoppage from backwater, the river (Wateree) being said to rise 30 feet at times. The available fall here is said to be 18 feet, subject to reduction by high water. Farther up the stream, and just above the mouth of Little Pine Tree creek, there was formerly a mill, using, it is said, a fall of 16 feet, and above it was a second mill with 15 feet, neither of which is now in existence. The fall in the six miles just above the mouth of Little Pine Tree is stated, and doubtless accurately, at 30 feet, and these two sites are said to be the best on the stream. The lower one had a race a mile long, but the upper one had none. Above the latter there are two grist-mills in operation. There is no doubt that this stream is an excellent one for manufacturing purposes, and that large amounts of power could be obtained from it at the two sites near Camden, especially as it would probably be practicable to secure ponds sufficiently large to store all the water during the night. According to what has been said on pages 61, 62, 84, and 85 regarding these sand-hill streams, and the data which have been obtained regarding their flow in the cases of the tributaries to the Cape Fear, Yadkin, and Savannah (see page 87), it would seem a fair allowance, if we assume them to discharge at their minimum about half a cubic foot per second per square mile, at their low-season flow 0.65, and at their ordinary flow 0.75 to 1 cubic foot. If this is correct, the flow of the Big and Little Pine Tree creeks would be as follows:

Table of estimated flow and power of Big and Little Pine Tree creeks.

Place and stream.	Drainage area.	Rainfall.					Flow per second.			Horse-power, gross.		
		Spring.	Summer.	Autumn.	Winter.	Year.	Minimum.	Low season.	Average.	Minimum.	Low season.	Average.
	Sq. miles.	In.	In.	In.	In.	In.	Cubic feet.	Cubic feet.	Cubic feet.	1 foot fall.	1 foot fall.	1 foot fall.
Big Pine Tree at mouth	55						28	36	55	3.2	4.1	6.3
Big Pine Tree above junction of Little Pine Tree	43	12	14–15	10	13	50	22	28	43	2.5	3.2	4.9
Little Pine Tree at mouth	12						6	8	12	0.7	0.9	1.4

It must not be forgotten that these powers can be doubled by storing the water during the night, which would be doubtless practicable. Neither must it be forgotten that the maps are not accurate, and the drainage areas are subject to error. The above estimates were made independently, by comparison with other streams. It may be remarked, however, that Mr. J. Millar Williams, the owner of the mill below the mouth of Little Pine Tree creek, and a civil engineer by profession, gauged the stream once, and found that the whole stream would afford 6.25 horse-power per foot, which agrees almost exactly with my estimate in the last column. John McRae, esq., of Camden (civil engineer), estimates the flow of the stream above Little Pine Tree creek at 100 cubic feet per second. At the time I saw the stream (February, 1881) it was discharging a little more than two-thirds of this, according to a rough measurement. The two sites above mentioned—above the mouth of Little Pine Tree—are doubtless worthy of attention, and are probably the best sites in the vicinity of Camden.

Little Pine Tree creek, although a strong, constant stream, like the Big Pine Tree, is much smaller, and its available power is not of very much value. It was at one time used to run a cotton factory using 20 feet fall and 30 or 35 horse-power, and the same site is now used by a grist-mill (1 run) and 2 cotton-gins, using 16 to 17 feet fall and perhaps 20 horse-power. The pond is 1 mile long and 400 feet wide, and the dam of earth 18 feet high. On these streams good foundations for dams can always be had on the impervious stratum forming the bed.

The other tributaries to the Wateree furnish also good powers no doubt, but regarding them no detailed information could be obtained. Toward the upper limit of the sand-hill belt the streams become very variable in their flow, and are notably inferior in capacity to the sand-hill streams. The next creek worth speaking of is Rocky creek, which flows for its whole length in Chester county. Draining an area of about 185 square miles, and situated

entirely above the sand-hill belt, it has a considerable fall, especially in the lower part, where it passes over the same rock formation which gives rise to the Great falls on the Catawba, and where there are several fine sites not used. There are several grist- and saw-mills on the stream, but none of much importance, and they are sometimes obliged to stop at low water. In the table on page 101 I have given my estimate of the available power per foot fall on this stream at its mouth.

Fishing creek, which enters the Catawba a few miles further up, is similar in many respects to Rocky creek. It rises about the center of York county and flows southeast through York and Chester, draining a total area of about 223 square miles. It is utilized for several grist- and saw-mills, and at present two cotton factories are being built on it. At Cedar shoals, a few miles from the mouth of the stream, Captain O. Barber is erecting a mill, to be run with the Clement attachment, and to use a fall of 10 feet, with a dam of the same height, built of wood and stone, and 300 feet long. I have estimated the available power at this place at about 25 horse-power at its minimum and 54 horse-power at low seasons in dry years. Further up the stream Mr. F. Barber is putting up a second factory, to use 29½ feet fall. The dam is of wood and stone, 200 feet long and 6 feet high, and the race is 750 feet in length. The available power will probably not exceed 75 horse-power at low water in dry years. The grist-mills on this stream have generally two pair of stones, and can run nearly all the time. Estimates of the flow of this stream will be found in the table.

There are no other tributaries to the Catawba worthy of special mention till we come to the South fork, which enters the main stream just at the state-line, and which is noted for its water-power. It is formed near the center of Catawba county by the union of two forks, Henry's and Jacob's forks, both of which take their rise among the mountains in the southern part of Burke county and flow nearly east into Catawba county. From the junction of these forks the river pursues a course a little east of south through Catawba, Lincoln, and Gaston counties, entering the Catawba river at the southeastern corner of the latter, after draining a total area of about 730 square miles. Its tributaries, with the exception of the forks above mentioned, are all small streams, not worthy of special notice. The river passes within a mile or two of Lincolnton and within 3 or 4 miles of Newton, the county-seats of Lincoln and Catawba counties, respectively, and the most important towns in the vicinity. The character of the drainage area and of the stream, differing in no particular respect from that of the Catawba river in its course in North Carolina, need not be described in detail. The rainfall is about 51 or 52 inches, distributed as follows: spring, 12; summer, 14; autumn, 10; winter, 16.

The stream has a rapid fall from Lincolnton down to its mouth, as will be seen from the following table, and in fact it is nothing but a series of rapids between those points, with few bottoms subject to overflow. From Lincolnton up to the junction of Henry's and Jacob's forks it is flat, with no large powers, and with considerable areas subject to overflow.

Table of declivity on the South fork of the Catawba.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Difference of level between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Crossing of Charlotte and Atlanta Air-line railroad	8	610			
			17	94	5.5
Crossing of Chester and Lenoir railroad	25	704			
			6	45	7.5
Crossing of Carolina Central railroad	31	749			

There are no reliable records of gaugings of the river. The stream is subject to heavy freshets, which overflow the banks in places, but the fall is so rapid below Lincolnton that the rise is not extreme in that portion of its course. The bed is uniformly rock at the shoals, overlaid between by gravel, clay, and sand. The stream is easily accessible from three railroads, as the map shows. The Chester and Lenoir narrow-gauge road, now in course of construction, will do much toward opening up the resources of the region along this stream, as well as on the Catawba and the Yadkin.

The powers on this stream are as follows, in their order, ascending:

1. Stowesville cotton factory (T. A. Gaither, Charlotte), 3 miles from Garibaldi, a station on the Atlanta and Charlotte Air-line railroad. The dam is of crib-work, extending in a broken line across the stream between islands, its total length being about 800 feet, and its height 4 feet. It was built in 1858, and cost $1,000. It backs the water half or three-quarters of a mile with a width of 150 to 200 feet, the natural width of the stream. A race 500 to 600 feet long gives a fall at the wheel of 11 to 12 feet, the power used being perhaps 25 to 30 horse-power for the factory. Near the latter is a grist-mill, and on the opposite side of the river a saw-mill and cotton-gin, the total power used being perhaps 70 to 80 horse-power. The factory is run night and day, and there is always waste of water. My estimate of the power available at this place will be found in the table.

2. Spring shoals (R. Y. McAden, Charlotte), 1½ miles from Lowell, on the Charlotte and Atlanta Air-line railroad, and above the mouth of Duhart's creek. This is one of the best sites on the river, and is now being improved by Mr. McAden, who is putting up a cotton factory there. The fall of the shoal is about 24 feet in all,

and in less than half a mile there is said to be nearly 30 feet fall over a ledge of solid rock, with rock banks, very favorable for building on one side. The dam extends diagonally across the stream, and is of timber bolted to the rock, the new dam having been built in 1881, at a cost of $1,200. It is 600 feet long and only 2½ feet high, backing the water three-fourths of a mile. A race 350 feet long, 50 feet wide, and 6 feet deep leads to the factory, where the fall is 23 feet. It is intended to use 200 horse-power, which it is expected to get at all times. The table gives my estimate of the power available. This shoal is in the middle of the cotton-belt, with good building-stone (gneiss) near by, an abundance of timber, and in a very healthy country.

3. The Massey shoal, an unimproved site, a mile above Spring shoal, with a fall of about 4 or 5 feet in a distance of 1,000 feet. This, with the two succeeding powers, belong together, as will be noticed below.

4. Mill of the Lawrence Manufacturing Company, a cotton factory (5,000 spindles), using a fall of 8 feet and about 60 horse-power. The dam is of wood, 600 feet long, 5 feet high, extending diagonally across the river, and ponds the water about a third of a mile, to the next dam above. It was built in 1877, and cost $1,750. The race is about 400 feet long. Water always wastes. Opposite it stood once an old mill, now almost all washed away.

5. Mills of the Woodlawn Manufacturing Company, a cotton factory (2,500 spindles and 50 looms), cotton-gin, grist- and saw-mill, with a fall used of 8 or 9 feet, and in all 100 horse-power. The dam is of logs, 600 feet long, 5 feet high (on both sides of an island), and backs the water 3 miles. It was built in 1852. Full capacity can always be secured, and water always wastes. Both factories are run 23 hours out of the 24.

The three powers last mentioned belong to the Woodlawn and Lawrence Manufacturing Companies and the Lawrence Water-Power Company, of Lowell, Gaston county, North Carolina, of all of which C. J. Lineberger is president, and they really form one continued shoal, with a gradual fall over a gravel bottom of 26 feet in a distance of a little over a mile, from the Woodlawn dam to the foot of the Massey shoal. The site is not far from Lowell, which is 16 miles southwest of Charlotte, on the Atlanta and Charlotte Air-line railroad. The fall from the Woodlawn pond to the tail-race of the Lawrence mill is 16.9 feet, and to the foot of the Massey shoal 25.9 feet, according to a recent survey, the results of which were furnished by Mr. N. Dumont, the manager of the companies. It is proposed to utilize some of the surplus power at this place, if possible, and the company promises liberal inducements to capitalists. My estimate of the available power (which, by the way, is considerably smaller than that of the company) will be found in the table.

6. Island Creek cotton-mills (J. H. Wilson, jr., Gastonia), 3 miles further up, and just below the mouth of Long creek, a considerable tributary, using a fall of 14 feet and 75 horse-power.* The dam is a wooden-frame dam, 600 feet by 4 feet, built in 1874, from which a race 190 feet long leads to the wheel. The mill is run 14 hours out of the 24, and there is always a surplus of water. The fall here might be increased, it is said, the available fall being stated at 16 to 18 feet, and even more. There is considerable fall below the mill, which is therefore never troubled with high water.

7. The next is an unimproved site with about 4 feet fall, where there was formerly a mill.

8. Friday shoals, not improved—a rock shoal, said to have 10 feet fall and to be a good power. It is below the mouth of Kettle Shoal creek, and 1 mile from the Chester and Lenoir railroad.

9. The next power is High shoals, one of the best powers on the stream. It is situated between the mouths of Kettle Shoal creek and Hynes creek, 7 miles from Lincolnton and 1 mile from the Chester and Lenoir railroad, which crosses the river just below it. The stream here flows over a ledge of solid gneiss-rock, the fall being about 22 feet in 300; but the fall continues below for some distance, amounting to 27 feet in 600, and probably 35 feet in a quarter of a mile or a little over. The banks are quite abrupt on both sides, but there is still abundance of room for building, the best location being on the left bank. The whole flow of the stream can easily be controlled, the facilities being in all respects most excellent. The width of the stream is 300 feet above the fall, and probably greater below, the channel being cut up with islands and rocks. Just below the principal fall a small creek enters the river from the left, which could be utilized well as a tail-race if the mills were situated on the hill by which it flows. This power was used till about ten years ago to drive iron works—rolling-mill, nail-factory, and others—together with a grist- and a saw-mill, situated on the left bank, and using together 180 horse-power. Now it is used by a small grist- and saw-mill, with a rough wing-dam at the head of the falls, and using a fall of about 20 feet. The ruins of the old iron works are still to be seen, and it is evident that they utilized a fall of between 22 and 27 feet. In the table I have given the drainage area above this place and the estimated available power. In the immediate vicinity of this place are some of the most noted deposits of iron ore in the state, and the place is especially adapted for the iron manufacturer. The Chester and Lenoir railroad will afford the best facilities for transportation.

10. Paper-mill (W. & R. Tiddy, Charlotte), called Long Shoal mills, situated below the mouth of Indian creek, and within a few miles of Lincolnton. The banks are favorable for building on the left, where the mill is situated. The dam is of wood and stone, about 1,200 feet long and 8 feet high, with a pond of 30 acres and a head-race of 300 feet. The fall used is 11 feet, and the power 150 horse-power, which can only be obtained nine months of the year, the average for the remaining three being about 112 horse-power. In dry weather there is no waste at all, the mill running 24 hours.

* In statistics by special agent on cotton-mills, fall stated as 25 feet and 40 horse-power.

11. Mosteller's shoals, unimproved, about half a mile above this, have a fall of 7 feet or so over a rock bottom.

12. Paper-mill (W. & R. Tiddy, Charlotte), 4 miles from Lincolnton. The dam is of wood and stone, 276 feet long and 8 feet high, with a head-race of 100 feet, the fall used being 10 feet, and the power 120 horse-power, which can always be obtained, but with no waste in summer. The mill is run 24 hours.

13. Half a mile above the last mill is the site of the old Lincoln factory, with a fall of about 8 feet and good building facilities. It is now utilized to drive a chair factory. A log dam, 560 feet long and 4½ feet high (built in 1875 at a cost of $1,000), turns the water into a race 300 feet long. The fall used is 8 feet, and the power 50 horse-power, the mill running 10 to 15 hours out of 24, and the water being partially stored during the night in very dry weather. This power (as well as No. 12, probably) is above the mouth of Indian creek, but below that of Sand branch.

14. The next power is the cotton factory of Phifer & Allison, using a fall of 6½ feet and about 50 horse-power, which can be obtained all the time. Above it is a saw-mill, grist-mill, and cotton-gin, using 4½ feet fall and 30 horse-power, subject to stoppage by backwater, and farther up are small grist-mills and saw-mills, which it is not necessary to refer to.

It will be seen that the south fork of the Catawba is an excellent stream for power, a large amount of which is already utilized. The climate in the vicinity is salubrious, the agricultural and mineral resources of the country very large, and the facilities for manufacturing in all respects hardly to be excelled.

Summary of power (estimated) on the south fork of the Catawba.

[Powers are for natural flow, without drawing down water at night in pond.]

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	Sq. ms.	In.	In.	In.	In.	In.	Feet.	Feet.						Feet.		
Stowesville cotton factory, etc.	6±	720	12	14	10	16	52	12.0	....	180	240	875	280	70–80	11–12	55	
Spring shoal	8±	688	12	14	10	16	52	24.0	500±	350	450	1,700	500	200	23.0	78	Solid rock.
Massey shoal	9±	675	12	14	10	16	52							0	0.0		
Lawrence Manufacturing Company.	9.5	675	12	14	10	16	52	25.9	5,000±	375	480	1,800	550	60	8.0	60	
Woodlawn Manufacturing Company.	10±	675	12	14	10	16	52							100	8.0		
Island Creek mills	13±	640	12	14	10	16	52	18.0+	....	240	320	1,200	375	75†	14.0†	42	
Unimproved site	......	600±	12	14	10	16	52	4.0	....	50	70	240	75	0	0.0	0	
Friday shoal	20±	550	12	14	10	16	52	10.0	....	100	150	560	175	0	0.0	0	
High shoal	22±	518	12	14	10	16	52	27.0	600	280	380	1,400	450	25	20.0	21	Rock.
W. & R. Tiddy's paper-mill	......	493	12	14	10	16	52	11.0	....	100	140	550	150	150	11.0	200	112 horse-power, three months; mill runs 24 hours.
Mosteller's shoal	......	450±	12	14	10	16	52	7.0	....	60	85	325	100	0	0.0	0	Rock.
W. & R. Tiddy's upper mill	......	430	12	14	10	16	52	10.0	....	80	115	450	130	120	10.0	192	No waste in summer, 24 hours run.
"Old Lincoln factory"	......	400+	12	14	10	16	52	8.0	....	60	80	325	90	50	8.0	118	Mill run 12 hours. No waste in dry weather.
Phifer's cotton factory	......	325	12	14	10	16	52	6.5	....	40	55	200	60	50	6.5	183	

* See pages 18 to 21. † See description.

Dutchman's creek enters the Catawba just above the crossing of the Carolina Central railroad, and is the next tributary worth mentioning above the South fork. It rises in Lincoln county and flows nearly south, and is a small stream, with only one power worth referring to, viz, Rhyne's cotton factory, close to the mouth, where a fall of 8 feet is used, 50 horse-power being obtained for nine months and 35 for the rest of the time, a steam-engine being used during that time; no water waste in dry summers, the mill being run all the time. There is some trouble with high water, the stream being subject to heavy freshets, and there not being many low grounds subject to overflow. The stream drains an area of about 88 square miles. Above Rhyne's factory are only saw- and grist-mills, the latter generally with two pair of stones. There are some sites not occupied where there have formerly been mills. The dams are all wood, founded on rock, and sometimes bolted down. The stream averages 100 feet in width for some distance from its mouth. On one of the tributaries of the stream a small amount of power is used for an iron-furnace.

There are no important tributaries to the Catawba in Mecklenburg, Catawba, and Iredell counties, the small streams which join the river being only capable of running small grist-mills with one or two pair of stones, for which purpose they are in some cases used. The tributaries from the north are more important. The three Little rivers—Upper, Middle, and Lower—have considerable fall, but are very small streams, draining, respectively, 31, 31, and 53

square miles. On Lower Little river there are several grist-mills and one cotton factory near Taylorsville, with a fall of 12 feet and a small amount of power, and the other two are utilized by grist- and saw-mills. These streams can probably hardly be depended on for one horse-power per foot fall in dry seasons at their mouths. The tributaries in Caldwell and Burke counties are of more importance. Gunpowder creek, from the north, drains an area of about 31 square miles, and is about like the Little rivers. Lower creek, from the same side, drains 117 square miles, but is said to have little power. John's river, also from the north, drains 120 square miles, but is not used except for one mill, although it has considerable fall. Upper creek (north side) drains 45 square miles, and has a cascade about 18 miles from Morganton, but of no value for power. Linville river (north side) drains 61 square miles, flowing through a very narrow valley, and has a cascade about 28 miles from Morganton, but which, like that of Upper creek, is of no value for power. It has one mill near the mouth. The tributaries from the south are more sluggish, but on Hunting creek there is a grist-mill. Silver creek is very sluggish.

In McDowell county the character of the streams is the same. Those which rise in the mountains are small, and are subject to considerable fluctuations in volume, but have a very large fall. Major Wilson, for example, has a mill on Mill creek with a fall of 46 feet, and he calculates that the power is 75 horse-power at all times. There are many other similar sites in the mountains. North Cove creek, which drains about 83 square miles, is said to be a good stream, and it has one good shoal not far from its mouth, where there were formerly iron works. All these streams are, in fact, a succession of shoals, but the powers are all small, and many are very inaccessible. That they have a rapid fall will be seen from the fact that the elevation of the gap at the head of Linville river is 4,100 feet, and that of the gap at the head of the North Catawba 3,407 feet.

Before leaving the Catawba river it must be remarked that few rivers present so many fine powers and so many advantages of all kinds for manufacturing. The stream seems destined, with the great interest now being taken in manufactures in the South, to become a great manufacturing river.

Table of flow and power (estimated) on the tributaries to the Wateree and Catawba rivers.

Name of stream.	Drainage area.	Rainfall.					Flow per second.*				Horse-power available, gross.			
		Spring.	Summer.	Autumn.	Winter.	Year.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.
	Sq. ms.	In.	In.	In.	In.	In.	Cu. ft.	Cu. ft.	Cu. ft.	Cu. ft.	1 ft. fall.	1 ft. fall.	1 ft. fall.	1 ft. fall.
Big Pine Tree creek	55	12	15	10	13	50	(†)							
Little Pine Tree creek	12	12	15	10	13	50								
Rocky creek	185	12	13	10	14	49	18	25	160	30	2.0	3.0	18.2	3.4
Fishing creek	223	12	13	10	14	49	25	40	200	50	2.8	4.5	22.8	5.6
South fork, at mouth	730	12	14	10	16	52	130	175	650	200	14.7	19.8	73.8	22.7
Dutchman's creek	88	12	14	10	16	52	10	15	75	20	1.1	1.7	8.6	2.3
Sugar creek	380	12	14	10	15	51	50	60	330	70	5.6	6.8	37.5	8.0
Lower Little river	53	Flow in dry seasons only sufficient to run small mills with the falls in use: varies from one-tenth to one-fifth of a cubic foot per second per square mile in dry seasons.												
Middle Little river	31													
Upper Little river	31													
Gunpowder creek	31													
Lower creek	117													
John's river	119													
Upper creek	45													
Linville river	61													
Mill creek	24													
North Cove creek	83													

* See pages 18 to 21. † See page 97.

THE CONGAREE RIVER.

The Congaree is formed by the junction of the Broad and the Saluda rivers between Lexington and Richland counties, South Carolina, whence it flows in a general southeasterly direction, forming the boundary between Richland county and the adjacent counties of Lexington and Orangeburgh, uniting with the Wateree to form the Santee. Its course is quite tortuous, and its length, measured in a straight line, is about 32 miles, while it is 60 by the course of the river. The principal town on the stream is Columbia, the capital of the state, with a population of about 10,000, and situated just below the junction of the Broad and the Saluda. The stream is navigable up to Granby, between 2 and 3 miles below the city, and its course lies almost entirely through the sand-hill belt, which extends up to Columbia, at which place the river crosses the fall-line, giving rise to the only power on the stream, and below which the stream resembles the Wateree below Camden, or the Pee Dee below Cheraw, in all essential points. The swamp-lands on the Congaree are, however, more extensive than on the Wateree, and from Granby

down to McCord's ferry, 28 miles, they average 4 miles in width and cover 50,000 acres, while on the Wateree they are not over 2 miles wide. The rainfall on the drainage-basins of the Broad and the Saluda is about 51 inches, distributed as follows: spring, 13; summer, 13; autumn, 9 to 10; winter, 15 to 16. The elevation of the river at the crossing of the Charlotte, Columbia, and Augusta railroad, below the falls at Columbia, is 129 feet above tide. The total drainage area of the stream is 7,965 square miles.

It only remains to describe the power at Columbia. About sixty years ago, the state of South Carolina having appropriated a million dollars for rivers and canals, a canal was built on the north side around these falls extending from Granby to the junction of the Broad and the Saluda rivers, at the upper end of the city of Columbia, and subsequently extended for more than two miles up the Broad river, the object being to secure an uninterrupted water communication from that stream, which was navigable for bateaux, to the sea, the original dimensions of the canal being as follows: width at top, 15 feet; at bottom, 8 feet; depth, 4 feet. This canal was gradually abandoned as railroads were introduced, and is now only used as a race to supply a small amount of power to the city water-works and to the state penitentiary, and occasionally navigated by bateaux down as far as the center of the city, the remainder being filled up and overgrown with trees, some of which are even 6 inches in diameter. Until 30 years ago it was much used by pole-boats and "match" boats. In 1868 the canal, with all its appurtenances, was sold to William Sprague, of the A. & W. Sprague Manufacturing Company, of Providence, Rhode Island, on condition that he should improve it, in default of which the property should revert to the state. A company was incorporated under the name of the Columbia Water-Power Company, but no improvements being made up to 1878 for various reasons, among which was the failure of the A. & W. Sprague Manufacturing Company, the state took possession of the property, agreeing to give to the Water-Power Company 500 horse-power whenever the power should be developed. The state proceeded to take steps toward the development of the power, and a survey and report were made by Byron Holly, civil engineer, who proposed to build a dam on the Broad river at the head of the canal, carrying the water to the city by a canal 150 feet wide at the top, 110 at the bottom, and 10 feet deep. While the matter was under discussion a new plan was proposed by Thompson & Nagle, architects and mill-engineers of Providence, Rhode Island, and finally, in December, 1879, a bill was passed by the legislature and a charter granted incorporating the Columbia and Lexington Water-Power Company, the state granting to Thompson & Nagle various rights, lands, and franchises, including the exclusive right to build dams on either the Broad or the Congaree river, exemption from taxation for 10 years on all improvements, and the free use of 250 able-bodied convicts for 3 years, together with other privileges. They prepared very elaborate plans and estimates for the work, and issued an elaborate "Prospectus of the Columbia and Lexington Water-Power Company", containing all the available information regarding the power, history of the canal, maps and views of the river, and details of the proposed improvements, all prepared at great cost. They have permitted me to make free use of this prospectus in the preparation of this report, and from it I have obtained these notes regarding the history of the power, as well as what follows regarding its technical features. But notwithstanding these elaborate and costly preparations the power remains undeveloped, fine as it is, and favorable as are all the collateral advantages.

Such is the history of the canal. It remains to present its technical features. Its total length is 5½ miles, and its fall 36 feet. Thompson & Nagle proposed two plans for developing power, and submitted estimates for the same. The first contemplated the construction of a dam across the Congaree just below the junction of the Broad and the Saluda, giving a fall at the foot of Gervais street of 22 feet at mean low water, and by carrying the canal 11,160 feet farther down an average fall of 27½ feet (the fall in the river between Gervais street and Granby being 13 feet), in addition to which a canal on the opposite side of the river was projected. The dam was to be 1,330 feet long between abutments, the bulkhead 200 feet long, and the total length of canal (on the Columbia side) 3 miles. The estimated cost of the whole improvement (not including the canal on the other side of the river, which was not intended to be built at first), including a mill with 864 looms and 26,112 spindles, was $1,699,848. It was considered best, however, to extend the canal at first only seven-eighths of a mile below Gervais street, the cost for this project being $1,555,764. The second plan proposed the erection of a dam across the Broad river alone at the head of the navigation canal, the canal being carried to a point seven-eighths of a mile below Gervais street. The length of the dam would be 650 feet between abutments, the bulkhead, as before, 200 feet long, the canal 4 miles long, and the fall at Gervais street 34 feet at mean low water, the total cost of this plan being estimated at $1,711,124. Both plans proposed a canal 200 feet wide. If in the last plan, however, the canal be assumed to be 150 feet wide, the estimated cost is $1,594,124.

The river opposite Columbia flows over a bed composed of ledges of rock, overlaid in places with deposits of sand and gravel. The stream is subject to heavy freshets, the most notable ones having occurred as follows: in May, 1840; in August, 1852; in 1856 the water rose 25 feet at Columbia; and in January, 1865, it rose 30 feet at the same place.

The drainage area of the Broad river is about 4,950 square miles, and that of the Saluda 2,350; so that the total drainage area of the Congaree above Columbia is about 7,300 square miles. The rainfall on the basin of the Broad is as follows: spring, 13; summer, 13; autumn, 10; winter, 15; total, 51 inches; and on that of the Saluda as follows: spring, 13; summer, 13; autumn, 9; winter, 16 inches. In regard to the flow of these streams I have no

accurate data; but it has been estimated by other engineers, and in regard to these estimates I feel constrained to say a few words, as well as to make a few general remarks on the subject of estimates of flow. In making my own estimates, hitherto given, I have proceeded according to principles which have been fully explained on pages 16 to 21. I have repeatedly called attention to the fact that they are only to be regarded as rough approximations, and I believe them myself to be rather under than over the mark. Without a single series of gaugings in this part of the country, with few extended observations of rainfall, and with by no means a perfect knowledge of the country, it is impossible to present anything very accurate. Before presenting my estimates for the Broad and the Saluda rivers I desire, therefore, to show briefly by what considerations I am led to them, principally on account of the fact that my estimates are very much lower than those which have been heretofore made. For this purpose I select a few typical streams for comparison and present in tabular form the various facts which are to be taken into consideration (page 104). From this table it will be clear that in estimating the minimum flow of the Broad and the Saluda the Merrimac and the Connecticut cannot serve as guides, on account of their large flow, probably due to the lakes and artificial reservoirs in their basins. It is further clear that from the size of the drainage area, when it exceeds about 1,000 square miles, no sure conclusion can be reached, for the Potomac, with the largest drainage area, has the smallest flow. It is difficult to explain the small flow of this river, considering the large area drained, although it may be due to the topography of the country and to the way in which the rainfall is distributed through the year, as will be shown when that river is considered; but whether the low flow is to be ascribed principally to these causes it is impossible to say. Comparing all these points, it would seem reasonable to take the minimum flow of the Broad and Saluda at 0.20 to 0.25 cubic feet per second per square mile. I have taken 0.23 for the Broad and 0.21 for the Saluda. As regards the minimum low-season flow, the rainfall being 51 inches, perhaps 14 or 15 inches may be considered as flowing off in a dry year (nearly $0.7 \times 0.40 \times 51$), or 1.3 inches per month, equal to 1.15 cubic feet per second per square mile, for which we take 1.10. It remains to determine the proportion of this flow in the driest month. Compared with the Merrimac and Connecticut, the flow of the Schuylkill appears very large, considering that it has no lakes. On these water-sheds more rain falls in summer than in winter, while on the Broad and Saluda the opposite is the case. There being no lakes to regulate the flow, these last streams will therefore get proportionately lower in summer, so that under these circumstances 0.27 to 0.30 does not seem too small a fraction for the driest month. We take 0.28, giving 0.30 cubic feet per second per square mile for both streams. For dry years, but not the driest, we take 0.35. Finally, as regards the maximum with storage, it is clear that the figures for the Merrimac and Connecticut cannot be applied to the Broad and Saluda on account of the influence of the lakes on the former streams. On the other hand, the climatic and other conditions in the Schuylkill basin seem quite similar to those of the latter streams, except that the rainfall in the former basin is greatest in summer (when the evaporation is greatest), while in the latter it is greatest in winter (when the evaporation is probably least). From this it seems legitimate to conclude that a larger proportion of the rainfall would be available in the latter case (supposing the conditions of evaporation to be the same in both cases); but, on account of the larger drainage area of the latter streams, and the fact that storage is only practicable in their upper parts without overflowing fertile bottom-lands (counted as the best farming-lands in the state), and that consequently the stored water would have a considerable distance to pass over before reaching Columbia (losing thereby considerably in volume by evaporation), it would seem safe to take the proportion of the rainfall available in the latter case as the same or even a little smaller than in the case of the Schuylkill. I take 22 per cent., or about 12 inches, as available.

Such are the considerations on which the estimates are founded. In fact, 8,000 cubic feet per second, which has sometimes been taken as the low-season flow of the Broad river, would be nearly the average flow of the stream, supposing half the mean annual rainfall on the drainage-basin to be discharged, a quantity which it would be impossible to utilize. The following table gives the results of the calculations:

Table of power of Congaree river at Columbia.

State of flow (see pp. 18 to 21).	Drainage area.			Flow per second.			Horse-power, gross.			Horse-power available, gross.	
	Broad.	Saluda.	Both.	Broad.	Saluda.	Both.	Broad.	Saluda.	Both.	Broad.	Congaree.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*1 foot fall.*	*1 foot fall.*	*1 foot fall.*	*34 feet fall.*	*22 feet fall.*
Minimum	4, 950	2, 350	7, 300	1, 140	500	1, 680	130	57	191	4, 400	4, 200
Minimum low season				1, 480	700	2, 200	168	80	250	5, 700	5, 500
Maximum, with storage				4, 200	2, 000	6, 200	477	227	705	16, 000	15, 500
Low season, dry years				1, 730	825	2, 550	197	93	290	6, 700	6, 400

Nevertheless it is evident that the power at Columbia is very fine, with every collateral advantage. There is an abundance of room for buildings, with safe locations; railroad communication in four different directions; fine building-stone (granite of excellent quality) within the city and for several miles up and down the river, and a fine brick clay along the canal. Of the large power available only about 75 horse-power is used, there being one small

grist-mill, with a wing-dam and 3 to 4 feet fall, situated on the river, and on the canal the city water-works, using about 12 feet fall and 40 to 50 horse-power, and a small amount of power being also used from the canal at the city penitentiary to run a grist- and saw-mill and for hoisting rock from a quarry, the fall being 18 feet. At the head of the canal is a rough wooden wing-dam extending across to an island.

It is to be hoped that this magnificent power may soon be developed, and the hopes of the city of Columbia, so long deferred, at last consummated.

Comparative table of drainage areas of various streams.

Name of stream.	Drainage area.	Rainfall.					Minimum flow per second per square mile.	Proportion of mean monthly flow in driest month.	Rainfall available in very dry years.	Per cent. of mean annual rainfall available in very dry years.	Remarks.
		Spring.	Summer.	Autumn.	Winter.	Year.					
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cubic feet.*		*Inches.*		
Merrimac	4,136	11	11	12	10	44	0.53	0.38	21.13	48.0	Flow regulated by large lakes. Well wooded.
Connecticut	10,234	11	11	12	10	44	0.51	0.41	19.16	43.5	Many lakes in drainage-basin. Quite well wooded.
Schuylkill	1,800	11	14	10	9	44	0.21	0.38	9 to 12	20.5 to 27.3	No lakes. Tolerably well wooded.
Passaic	981	12	14	12	10	48	0.23				Several lakes of considerable size. Not very thickly wooded.
Delaware	6,500±	10	13	10	8	41	0.30				Many small lakes and ponds in basin. Very well wooded.
Potomac	11,476	11	12	9	8	40	0.09				No lakes. Narrow valleys. Considerable limestone formation.
James	6,800	12	11	8	10	41	0.19				No lakes. Valleys narrow in mountains. Well wooded.
Neuse	1,000	12	12	10	10	44	*0.16				No lakes. Soil much deeper than in rivers above. Very well wooded.
Broad	4,950	13	13	10	15	51	*0.23	*0.28	*12.00	*22.0	No lakes. Deep soil. Well wooded. Mountains not bald, but covered with soil. Evaporation probably smaller than on James.
Saluda	2,350	13	13	9	16	51	*0.21	*0.28	*12.00	*22.0	No lakes. Deep soil. Well wooded. Mountains covered with soil. Evaporation probably less than on James.

* Estimated.

TRIBUTARIES OF THE CONGAREE RIVER.

The Congaree river has no very important tributaries, only one of them, Congaree creek, being worthy of mention. Like the other and smaller streams flowing into the river, it is a sand-hill stream, and is only about 15 miles long, flowing for its entire length in Lexington county, and joining the river about 3 miles below the Columbia bridge. It is not a rapid stream, and flows for a considerable part of its course through swamps, over a sandy bed, and it is only on the upper half of its course that it offers any facilities for power. There are two sites now not improved, but formerly used for saw-mills, with brush-dams and races about a mile and a half long, the falls being about 5 to 8 feet. The stream drains an area of about 115 miles, according to the map I have used. If we take its flow, as in the case of the Pine Tree creeks (see p. 101), at a half to one cubic foot per second per square mile, it will afford at its mouth a power of 6.6 and 13.2 horse-power per foot fall, without storage during the night. The sites above named are 5 or 6 miles from Columbia, and 1 to 3 miles from the Charlotte, Columbia, and Augusta railroad. The owner, Mr. John Taylor, of Columbia, states that an engineer's survey found the flow to be 500 to 800 cubic feet per second, or 625 on the average—an evident impossibility, provided the drainage area above stated is correct, or it would correspond to an annual rainfall of 72 inches, all of which flowed off by the stream.

Red Bank creek, a tributary of Congaree creek, is another sand-hill stream, and on it is the Red Bank cotton factory, with a fall of 12 feet, and using 40 horse-power for nine months of the year and about 30 for the rest of the time, the water being drawn down in the pond at night, so that the natural flow of the stream in dry weather does not afford over 1 horse-power per foot fall. There are also two saw-mills on the stream. All the dams are of dirt, that of the factory being 25 feet wide at the bottom, 12 at the top, and 8 high. It may be mentioned as an interesting fact that wood can be obtained in this neighborhood at 75 cents a cord.

On some of the other sand-hill streams in the vicinity, such as Berry creek, power can be obtained to a small extent.

THE BROAD RIVER.

This stream takes it rise on the eastern slope of the Blue Ridge near Hickory-Nut gap, in the southwestern part of McDowell county and the northeastern part of Henderson county, North Carolina, and after flowing in a general southeasterly direction through Rutherford county and a corner of Cleveland county, North Carolina, and in South Carolina between the counties of York, Chester, Fairfield, and Richland on its left, and Spartanburgh, Union,

Newberry, and Lexington on its right, it unites with the Saluda river just above Columbia to form the Congaree. The length from source to mouth, measured in a straight line, is about 128 miles, but following the course of the river it is very considerably greater. There are no towns of any importance on the river. The stream is navigated to a certain extent by bateaux (carrying 30 to 40 bales of cotton, and drawing 20 inches when loaded and 4 inches when empty), the present head of navigation being about 141 miles above Columbia (by the river) and 28 miles above the North Carolina line. A survey was made of the river by the government in 1879-'80 for the purpose of ascertaining the practicability and probable cost of improving the navigation, and the report is found in the annual report of the chief of engineers for 1880, p. 1010, in which the cost of rendering the river navigable for pole-boats carrying from 70 to 90 bales of cotton is estimated at $90,000.

The Broad river drains a total area of about 4,950 square miles, of which 3,550 are in South Carolina and 1,400 in North Carolina. The river receives a number of important tributaries, as follows:

From the west, ascending the stream:	Square miles.
Enoree river, draining an area of	730
Tiger river, draining an area of	720
Pacolett river, draining an area of	475
Thicketty creek, draining an area of	100
Green river, draining an area of	198
From the east:	
Little river, draining an area of	203
Sandy creek, draining an area of	63
Bullock's creek, draining an area of	73
King's creek, draining an area of	72
Buffalo creek, draining an area of	178
First Broad river, draining an area of	302
Second Broad river, draining an area of	193

The general character of the drainage-basin resembles that of the Catawba. It lies entirely above the fall-line; is well wooded, especially in the upper parts; is without lakes; affords fine building-stone in numerous localities; and as regards soil, etc., is just like the valley of the Catawba. The rainfall and the flow of the stream have been discussed in detail in speaking of the power at Columbia. The bed of the stream is rock, clay, sand, or gravel, and in many places the banks are low and the bottoms overflowed in freshets. The declivity of the stream will be seen from the following table, which shows the fall to be less than that of the Catawba, but still very large:

Table of declivity of Broad river, South Carolina.

Place.	Distance from Columbia.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Congaree river, crossing of Charlotte, Columbia, and Augusta railroad	—2±	129.0			
			2.0±	6.5	3.25
Congaree river, foot of Gervais street, Columbia	0.00	135.5			
			2.75	26.5	9.36
Bull sluice	2.75	162.0			
			8.75	14.2	1.60
Ninety-nine islands	11.50	176.2			
			2.75	17.2	6.40
Ninety-nine Islands shoal	14.25	193.4			
			12.00	35.7	2.97
Foot of Summers' shoal	26.25	229.1			
			0.94	11.6	12.26
Head of Summers' shoal	27.19	240.7			
			13.81	29.0	2.09
Foot of Lyle's shoal	41.00	269.7			
			0.93	11.4	12.15
Head of Lyle's shoal	41.93	281.1			
			16.57	41.0	2.47
Foot of Neal's shoal	58.50	322.1			
			0.62	9.8	15.60
Head of Neal's shoal	59.12	331.9			
			9.13	8.0	0.87
Foot of the Gravel	68.25	339.9			
			0.75	6.1	8.14
Foot of Lockhart's shoal	69.00	346.0			
			1.41	47.7	33.80
Head of Lockhart's shoal	70.41	393.7			
			23.84	32.3	1.31
Foot of Ninety-nine islands	94.25	426.0			
			6.25	104.0	16.63
Head of Cherokee shoal	100.50	530.0			
			4.25	12.0	2.83
Crossing of Atlanta and Charlotte Air-line railroad	104.75	542.0			
			36.25	216.5	6.00
Green river	141.00	758.5			

The average fall between Columbia and the crossing of the Atlanta and Charlotte Air-line railroad (104.75 miles) is nearly 3.9 feet per mile, and thence to the mouth of Green river it is, as by the table, 6 feet per mile. Above that point the stream is a mountain torrent, the elevation of its headwaters being not less than 2,500 feet.

It will be seen from the map that the lower part of Broad river is very accessible, while that part above the mouth of the Pacolett is quite the contrary.

Proceeding up the river, the water-powers met with will now be named. Almost all the information I have regarding them is obtained from the report on the river above referred to. The shoals are tabulated below, and regarding most of them very few remarks can be made.

At Bull sluice the river is 200 yards wide, but exposed rocks extend from either side, leaving a straight sluice in the middle only 100 feet wide, through which the whole volume of the river pours at ordinary stages. Just above the sluice a ledge of rock extends across the river, which widens to 900 feet. The head of the Columbia canal is just above this sluice.

Ninety-nine Islands shoal is the next one of importance, the fall being 17.26 feet in 2¾ miles. It is used for power to a small extent, driving a grist- and saw-mill on the left bank, with a fall of 5 feet. The banks are favorable for building, and the power is no doubt easily available. The river is very wide, in some places over half a mile. The shoal is just above the mouth of Cedar creek, but its head is just below that of Little river.

Boney shoal, 17¾ miles above Columbia, is a mile long, with a fall of 6 feet, and is utilized by a small grist-mill.

At Alston, 25 miles from Columbia, the Greenville and Columbia railroad crosses the river, which is here 300 yards wide.

Summers' shoal begins 26¼ miles above Columbia and extends for a mile, the fall being 11.61 feet, part of which is used by a grist-mill. This shoal is said to be a fine site for power. It is 13 miles below the mouth of the Enoree river.

Lyle's shoal (41 miles) has a fall of 11.36 feet in 4,930 feet. It is situated 3 miles below the mouth of the Tiger river, and 1 mile above the mouth of the Enoree.

At Shelton, where the Spartanburgh and Union railroad crosses the river, the rise of freshets is 27 feet, the width of the stream being 250 yards.

Neal's shoal (58½ miles) has a fall of 9.75 feet in 3,300, and there is a grist-mill on each bank of the river, which is from 250 to 350 yards in width. This shoal is said to be favorable for power. It is situated 14 miles above the mouth of Tiger river, and about 9 miles below the mouth of Turkey creek.

The next shoal, really the first of great importance as a water-power, and perhaps the best site on the river, is Lockhart's shoal, situated less than 2 miles above the mouth of Turkey creek. This shoal is preceded by a short shoal called the Gravel shoal, which has a fall of 6.11 feet in 2,673 feet, just above which is Lockhart's shoal proper, which is "formed by the intrusion of two trap-dikes 500 yards apart, causing the bed of the river to be a field of jagged rock, much resembling the crater of an old volcano". The lower shoal is 2,955 feet long, with a fall of 15.80 feet, and the upper shoal is 3,000 feet long, with a fall of 31.86 feet; so that the total length of the shoal is 1.41 miles, and the fall 47.66 feet. The width of the stream above the shoal is 200 yards, and the depth 25 to 30 feet. Near the foot of the upper shoal the width is 500 yards. At the foot of the lower shoal the west bank is very hilly, and the east bank not quite so much so. The hills gradually recede on the west side, leaving a bottom 800 yards wide along the river, and gradually returning to the river near the head of the upper shoal. On the east bank the shore-line is irregular, and there are many high bluffs along the river. On the upper shoal there is in one place an abrupt fall of 5 feet, and two mills—one on each side of the river—utilize a small amount of the power.

These shoals being the most difficult on the river, a canal was built around them on the west bank by the state between the years 1818 and 1825, at a cost of $130,000, and it was used till 1852, when it was abandoned. Leaving the river a little below the head of the upper shoal, with a guard-lock of ordinarily small lift, it passes through the bottom above described, and after descending about 14 feet by a flight of two locks it meets the hills near the foot of the lower shoal and follows them to the river, into which it descends by four locks with about 28 feet lift. The total length of the canal is 7,869 feet, and the fall 45.78 feet. Its original dimensions were: width on top, 16 feet; at bottom, 8 feet; depth, 4 feet. At present the width at the bottom is 5 feet, and the depth 2.5 feet; and it is estimated that it would cost $3,794 to restore it to its original dimensions and to put the locks in order, the gates being gone and some of the masonry having been removed. These locks were 10 by 76 feet, and were built of first-class cut-stone masonry. The canal is now filled up with deposits and overgrown with trees.

As regards the availability of Lockhart's shoal for power, it must be stated that its extensive utilization is only possible on the west bank. The canal for the lower 600 yards of its course is built along the side of the hills on an embankment about 12 feet high, with small building-room between it and the river, the outlet-lock being only 16 feet and the lower flight of 3 locks (115 feet above the outlet-lock) only 110 feet from the river, while the upper flight of 2 locks is, perhaps, 400 yards from the same. Hence it would not be easy to utilize the whole fall of the shoal, but it is said that the fall of the upper shoal could easily be utilized, with abundance of building-room.

In the following table I have estimated the flow and the available power at this place, and the latter will be seen to be very large. The whole amount would, of course, only be rendered available by digging a large canal; for the present canal, if cleaned out to its original dimensions, would only carry about 70 cubic feet per second, with a fall of a foot to the mile.

This shoal is located in a very healthy part of the state, in the midst of the cotton-belt, and 8 miles from Union, the nearest railroad point. It is, without doubt, one of the finest powers in the vicinity.

Table of power available at Lockhart's shoal.

State of flow (see pp. 18 to 21).	Drainage area.	Fall.		Flow per second.	Horse-power available, gross.		
		Upper shoal.	Lower shoal.				
	Square miles.	*Feet.*	*Feet.*	*Cubic feet.*	*1 foot fall.*	*15.80 feet fall.*	*31.86 feet fall.*
Minimum	2,400	15.80	31.86	540	61.3	970	1,950
Minimum low season				720	81.8	1,300	2,600
Maximum, with storage				2,100	240.0	3,750	7,500
Low season, dry years				830	94.3	1,500	3,000

Above this shoal there is no power of importance for nearly 25 miles, the next of importance being a long shoal, 6¼ miles long, generally subdivided into two, the Ninety-nine Islands shoal, 3.2 miles long, with a fall of 50.62 feet, and Cherokee shoal, 2 miles long, with a fall of 50.95 feet. The head of the latter shoal is only about 3 miles below the crossing of the Atlanta and Charlotte Air-line railroad. Notwithstanding the large amount of power theoretically available at these shoals, only a small part of it can practically be utilized according to all that I could learn, the hills coming abruptly up to the river on both sides for almost the whole distance, and leaving no building-room except a small amount in a few isolated places, where power can be used to a certain extent. There are several grist-mills along the shoals in these places with small wing-dams and generally small falls, and there have been others, which are now abandoned. Of these sites for power probably the best is the one formerly utilized by the King's Mountain Iron Company, on the west side of the river, about 2½ miles above the foot of Ninety-nine Islands shoal. A branch of the river, about 80 feet wide, passes here between the shore and an island, the fall in the main river above the head of the island being about 5 feet in 500, and the fall in the branch about 16 feet in 800 to 1,000, making in all about 20 feet, which could be used with a 5-foot dam above the head of the island and favorable ground for building—not very high, but probably not often overflowed, on account of the rapid fall of the stream below. Not more than one-quarter or one-fifth of the volume of water in the river flows naturally to the west of the island, but more could be turned in by a dam. Were it not desired to utilize a large fall, 12 feet could be obtained very easily.

The fall between this place and the foot of the shoal, 2½ miles below, is about 28 feet, which has only been used in part by a few grist-mills. Above there is one place on the east side where there is a little building-room, and where it is proposed to erect a cotton factory, to use a fall of 9 feet, with a wing-dam 6 feet high and 120 feet long, the mill to be a yarn-mill, with 3,000 spindles. This site was formerly used by the King's Mountain Iron Company for their forges and furnaces, and is 1 mile below Cherokee ford. Opposite it there was once a saw-mill, using a fall of 5 or 6 feet. Both sites are on the lower part of Cherokee shoal.

About 300 yards above Cherokee ford, at the head of Cherokee shoal, were formerly located the works of the Magnetic Iron Company, now abandoned. The dam was a curved one, extending entirely across the river, being the only dam quite across, and was about 440 yards long and 10 feet high, built of crib-work bolted down to the rock foundation. It was first built in 1837, and was washed out in 1875, the works having been abandoned in 1870. The canal was 200 yards long, the fall at the lower end being 10 feet and the average fall 8 feet, and along it were situated the various mills, as follows: stamp-mill (8 to 10 horse-power), grist-mill (40 horse-power), machine-shop (20 horse-power), trip-hammer (40 horse-power), blast for forges (40 horse-power), rolling-mill (120 horse-power), nail factory (20 horse power), blast-furnace (50 horse-power), or a total of 340 horse-power, and with a surplus of water at all times. The dam backed up about a mile, with a width of 300 yards. The banks at this place are very favorable for building, and the available fall is greater than was used, amounting to some 16 feet in three-quarters of a mile, all of which is available, although the land is more favorable for building at the point where the old works were located. Below this the hills close in upon the river on both sides, and continue from there down to the foot of the shoal.

To recapitulate, then, regarding these two shoals, their complete utilization is impracticable on account of the abruptness of the banks, the impossibility of building a canal, and the small amount of building-room. In fact, it is said that there are only two places along the whole shoal, over 6 miles, where it is possible to get a road down to the river without considerable difficulty. At the head of Cherokee shoal, and in perhaps half a dozen places below, small areas of favorable building-ground are found where small mills might be located and some power obtained, the best place of the kind being, perhaps, the site of the works of the King's Mountain iron-works.

Surratt's shoal is the first shoal above the railroad, and is 1¾ miles long, consisting of a continuous series of ledges, the fall being stated to be not less than 20 feet to the mile. The river is 200 yards wide above the shoal, which is 3 miles above the mouth of Buffalo creek.

Gaston's shoal is 2¼ miles beyond, and is 1 mile long, with a fall of about 10 feet, of which 6 feet occur in the first 400 yards. The river is 300 yards wide.

Palmer's shoal, 6¼ miles further up, is said to be the best site above Cherokee shoal, the fall being 18 feet in half a mile. It is used by a grist-mill, with 6 feet fall, and there are fine building-sites on both sides of the river, the entire fall being available for power. It is situated about a mile above the mouth of the First Broad river.

Above Palmer's there is said to be no shoal of much importance till the mountains are reached, the fall of the stream being gradual, although considerable. Above Green river there may be some good sites, and also below; but none were specially mentioned by persons acquainted with the river.

The most noticeable fact connected with the water-power of the Broad river is that there is not a single dam entirely across the stream, notwithstanding its large fall and the large amount of power available on it.

The following table contains estimates of the power at the shoals of the river:

Table of power on Broad river.

Locality.	Distance from Columbia.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.	
	Miles.	*Sq. m.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*							*Ft.*	
Nigger shoal	1.25	4,950	13	13	10	15	51	2.5	750ft	(†)	(†)	(†)	(†)	(†)	(†)	
Bull sluice	2.75	4,950	13	13	10	15	51	4.37	1,050ft	(†)	(†)	(†)	(†)	(†)	(†)	
Ninety-nine Islands shoal	11.50	4,760	13	13	10	15	51	17.26	2.75m	2,150	2,800	7,950	3,250	50—	5	2.5—
Boney shoal	17.75	4,525	13	13	10	15	51	6.0+	....	700	925	2,600	1,075	50—	6	7.0—
Summers' shoal	26.25	4,480	14	13	10	15	52	11.61	0.94m	1,350	1,775	5,000	2,000	50—	....	4.0—
Lyle's shoal	41.00	3,490	14	13	10	15	52	11.36	4,930ft	1,050	1,350	3,800	1,600	....	....	......
Neal's shoal	58.50	2,590	14	14	10	15	53	9.75	3,300ft	650	850	2,550	1,000	75—	....	12.0—
Lockhart's shoal	69.00	2,400	14	14	10	15	53	47.66	1.41m	2,900	3,900	11,000	4,500	50—	...	3.0—
Ninety-nine Islands shoal	94.25	1,357+	14	14	10	16	54	50.62	3.20m	1,800	2,350	6,900	2,700	......	....	......
Cherokee shoal	98.50	1,357	14	14	10	16	54	50.95	2.00m	1,800	2,350	6,900	2,700	......	....	......
Surratt's shoal	108.00	1,142	14	14	10	16	54	35.0(?)	1.75m	1,000	1,250	4,000	1,450	0	0	0.0
Gaston's shoal	110.25	1,133	14	14	10	16	54	10.00	1.00m	280	360	1,150	400	0	0	0.0
Palmer's shoal	116.50	821	14	14	10	16	54	18.00	0.50m	350	420	1,500	475	50—	6	15.0 –
Between mouth and foot of Lockhart's shoal‡	2.75 69.00	4,950 2,400	14	13	10	15	52	184.00	66.25m	17,500	23,000	65,000	27,000	......	....	......
Between head of Lockhart's shoal and foot of Ninety-nine Islands shoal‡	70.40 94.25	2,400 1,370	14	14	10	15	53	32.00	23.85m	1,600	2,000	5,700	2,300	....	....	......
Between head of Cherokee shoal and mouth of Green river‡	100.50 141.00	1,357 236	14	14	10	16	54	228.00	40.50m	4,000	5,000	18,000	6,000	50—	6	1.5—
Total between mouth and mouth of Green river‡	2.75 141.00	4,950 236	13	13	10	15	51	596.00	138.25m	30,000	39,000	114,000	45,000	225	....	1.0—

* See pages 18 to 21. † Included in estimate for Columbia. ‡ Estimates in these lines of no practical value.

TRIBUTARIES OF THE BROAD RIVER.

The first important tributary of the Broad is the Enoree river, the largest one below it, viz, Little river, from the east, having no powers worthy of special mention.

The Enoree river rises in the northern part of Greenville county and flows southeast, forming the boundary between the counties of Greenville, Laurens, and Newberry on the south, and Spartanburgh and Union on the north, joining the Broad 40 miles above Columbia, after flowing a distance of about 70 miles in a straight line and draining an area of about 730 square miles. There are no towns on the stream, which flows through a hilly country, gently rolling but not very broken, the principal productions of which are grain and cotton. The bed of the stream is rock at all the shoals, but between them sand, clay, or gravel. The prevailing rock in all this upland country drained by the tributaries of the Congaree and of the Savannah is gneiss, the streams crossing the ledges nearly at right angles. Almost all of the water-powers of this part of the state are formed by the streams passing over these ledges of gneiss, and the falls are very often quite sudden. It is to be remarked, however, that the rivers in this section of the country are in many places rapidly filling up with detritus—sand and mud—which is washed in from the hill-sides, so that many shoals are being rapidly obliterated, and at many places, where within the memory of middle-aged men there were shoals with falls of from 5 to 10 feet, at present scarcely any shoals can be noticed. The cause of this is probably to be attributed, to a large extent, to the cutting down of the forests, by which the soil is divested of the roots, fibers, and mosses, which serve in so great a degree to hold it together and prevent its being washed away by sudden showers; also partly due, it is said, to a superficial method of cultivation, by which the soil is also rendered less cohesive and more liable to washing. This phenomenon is also noticeable in North Carolina, but not to such a marked extent as in the portion of the country we are now considering. It is very important to notice also that one effect of this silting up of the streams is to diminish the facilities for storage; for if artificial reservoirs are constructed, they soon fill up, and their capacity is greatly diminished. This effect will be noticeable on small streams, where artificial reservoirs could be located; and, in fact, it is said that many mill-ponds fill up so rapidly that they have to be cleaned out at short intervals.

The valleys of these streams are not especially favorable for reservoirs from a topographical point of view, although some sites could, no doubt, be found.

The Enoree has considerable bottom-land on its lower parts, more than most streams in this vicinity, and the banks are not often steep and hilly. In fact, along the banks of this stream are some of the finest and most fertile bottom-lands in the state. The stream is 75 feet wide at its mouth, and is navigable for pole-boats for a distance of 10 miles, the shoals which formerly existed in this distance being filled up. The rainfall on the valley is about 53 inches: 15 in spring, 13 in summer, 10 in autumn, and 15 in winter.

The elevation of the stream at the crossing of the Atlanta and Charlotte Air-line railroad is 842 feet, and at its mouth about 269 feet, giving a fall between these points of 573 feet, or about 7 feet to the mile. The stream is at present very inaccessible, but the new railroad from Spartanburgh to Greenwood, now being built, will cross the stream about the middle of its course.

The shoals on the lower part of this river are rapidly filling up, and in the first 25 miles there are only two small mills, with falls of 5 feet each. At "Musgrove's mill",* about 10 miles from Laurens, there is a grist-mill with 6 feet fall, the dam being 4 feet high, and there is said to be a fall of 4 feet additional below the mill. Four miles above is the first power of importance on the river, and between the two is a small shoal—Flat shoal—with a fall of 4 feet or so. At the other shoal, just referred to, the fall is said to be 16 feet, which is utilized by a small grist-mill. I am not able to locate this place exactly on the map, but as nearly as I can find the drainage area above it is between 350 and 400 square miles. I have therefore estimated the power to be as follows:

Power at Yarbrough's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power.	Horse-power.	Remarks.
	Sq. miles.	*Feet.*	*Cu. ft.*	*1 foot fall.*	*16 feet fall.*	
Minimum	375	16	62	7.0	112	Only 20 to 30 horse-power utilized.
Minimum low season			80	9.0	144	
Maximum, with storage			400	45.4	725	
Low season, dry years			97	11.0	176	

In regard to my estimates of the power on these streams of western South Carolina it must be remarked that they are liable to considerable error on account of lack of data for comparison. The powers stated to be utilized by various mills and factories are, in many cases, very large in proportion to the fall and the drainage area, and if they were taken as correct, the conclusion would be inevitable that these streams have a much larger flow per square mile of drainage area than those farther north, or even than those in New England, notwithstanding the lakes in the latter part of the country; and it may be that the effect of the depth of the soil and of the forests in South Carolina is larger than would be expected, and that the streams in question are quite constant in flow and are fed by perennial springs. But in the first place the powers stated to be used generally have reference to ordinary years, and even if water is scarce for a month or so in summer, it is rarely mentioned; secondly, the rated power of turbine-wheels is generally much too large; and thirdly, people generally have a tendency to overrate their powers, especially if they do not use quite the full power of the stream. I have therefore prepared my estimates from comparisons with streams of similar drainage area, and they must be looked upon as giving simply the power and flow which would be expected, reasoning from analogy, and not taking into account any abnormal circumstances, such as large springs, which may exist in some cases.

The next shoal above this one is Mountain shoal, the most important power on the Enoree. It is situated about 12 miles from Laurens, which is the nearest railroad point. The stream pours here over a ledge of gneiss-rock, falling nearly 70 feet in a quarter of a mile, but divided into two parts. At the head of the upper shoal a natural dam extends nearly across the stream, which is some 200 to 300 feet wide, and the stream falls 16.5 feet in 500, the whole of which fall can be easily used on the left bank, with safe building-sites, the right bank not being so favorable. A fall of 6 feet is used here by a cotton-gin with a wing-dam. After flowing 200 yards with a fall of only a couple of feet, the river flows over a second ledge of gneiss, falling 52 feet in 250 yards. At the head of this fall the stream is 300 feet wide, and a wing-dam, consisting simply of a log bolted to the rock, turns the water to the left bank, where a race 300 feet long affords a fall of 16.5 feet at the grist- and saw-mill below, although 25 feet could be obtained. The banks on the left are steep and rocky, while on the right they are lower, and at the foot of the shoal is a bottom which is sometimes overflowed to a depth of 5 or 6 feet. The channel of the stream is interspersed with islands, one at the foot of the shoal, on the left side, covering 12 acres at low water, and one at the head, on the right, covering 6 acres, with a narrow branch between it and the right bank. Some power could

*Mills states that at Musgrove's ford there is a fall of "26 feet in 14 chains". The falls have, however, doubtless changed considerably since his book was written.

be used at the site of the grist-mill with a fall of 20 to 30 feet, but the entire power could best be used on the right bank, with a canal 750 feet long, and without a dam of any consequence. The water could not be stored during the night, except above the upper shoal. Thus it would seem best to utilize the two shoals separately, by which means all the fall could easily be rendered available.

The following table gives my estimate of the power here, together with the drainage area and rainfall:

Table of power at Mountain shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Rainfall.					Flow per second.	Horse-power available, gross.		Utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.				Net horse-power.	Fall.
	Sq. miles.	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*	*1 ft. fall.*	*70 ft. fall.*		*Feet.*
Minimum	280	70	15	14	10	16	55	42	4.8	330	50	23
Minimum low season								56	6.3	450		
Maximum, with storage								300	34.0	2,400		
Low season, dry years								64	7.3	500		

This power is eminently worthy of attention, for it is in all respects an excellent one. Building-stone is near at hand, and the only objection to the place—its inaccessibility—bids fair to be removed by the construction of the Spartanburgh and Greenwood railroad, which will probably cross the river just at the shoal. The place is owned by Mr. W. A. McClintock, Mountain Shoal post-office.

Above this place come several small shoals—Kilgore's, Yarbrough's, Flemming, Wofford's, and Leatherwood's; but they are gradually being filled up and are disappearing, especially Kilgore's and the Flemming shoal, which are said to be worthless. The other three, none of which are used, are said to have falls of from 6 to 12 feet available. But the most important power is Van Patten's shoal, about 300 yards above Leatherwood's shoal, 15 miles above Mountain shoal (by river), and over 20 miles from Laurens. The river here falls over a ledge of gneiss-rock, as at Mountain shoal, the fall being 55 feet in 900 feet. Both banks are steep, and both could be almost equally well used for building; but the left bank is probably the more favorable if only a small amount of power is to be used, while if the total available power is to be utilized the right is perhaps better. However, the whole fall could be easily utilized. At present only a small portion is used by a small mill on each side. The river is about 150 yards wide at the head of the shoal.

Leatherwood's shoal, just below, is also available, the natural fall being 10 to 12 feet in 150 yards.

The following table gives my estimate of power, with drainage area and rainfall for these two shoals:

State of flow (see pp. 18 to 21).	Drainage area.	Fall.	Rainfall.					Flow per second.	Horse-power available, gross.			Utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.					Net horse-power.	Fall.
	Sq. miles.	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. feet.*	*1 ft. fall.*	*55 ft. fall.*	*10 ft. fall.*		*Feet.*
Minimum	234	Van Patten's, 55; Leatherwood's, 10–12.	15	14	10	16	55	35	4.0	220	40	50—	12 and 6
Minimum low season								47	5.3	290	50		
Maximum, with storage								250	28.4	1,550	280		
Low season, dry years								53	6.0	330	60		

Like Mountain shoal, this is a most excellent power, and worthy of attention.

The next shoal above Van Patten's is one belonging to the Pelham Manufacturing Company, and the fall available is 30 feet, with a 5-foot dam and a race 500 yards long through clay, according to the secretary, O. P. Jackson, esq. Just above it is the Buena Vista cotton factory, using a fall of 18 feet and 60 horse-power, with a dam 4 feet high, 120 yards long, and a race of 80 feet. In summer there is no waste except at night, when running full capacity, the mill being run 12 hours. In addition to the factory, there is a gin-, saw-, and grist-mill.

One mile above this is a shoal belonging to Dr. T. R. League, the fall being 23 feet in a distance of about 80 feet, with no dam, according to Mr. Jackson. These three shoals last mentioned are all about 11 miles from Greenville and 6 miles from the Air-line railroad at Greer's station.

Above this are several other shoals, one (Taylor's) about 8 miles from Greenville and half a mile above the railroad, and said to have a natural fall of 5 to 8 feet, capable of being increased by a dam. And there are several similar ones further up, including Bannister's, with a fall of 15 feet and a dam 9 feet high.

It will be seen that the Enoree river has a succession of considerable shoals affording excellent powers. Crossing the ledges of rock at larger angles than the Broad river, the falls of all these tributaries are more abrupt.

Table of power at Pelham for the three shoals mentioned.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Rainfall. Spring.	Summer.	Autumn.	Winter.	Year.	Flow per second.	Horse-power available, gross. 1 ft. fall.	30 ft. fall.	18 ft. fall.	23 ft. fall.	Utilized. Net horse-power.	Fall.
	Sq. miles.	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*						*Feet.*
Minimum	94	Pelham 30; Buena Vista factory, 18; League's shoal, 23.	16	14	10	16	56	10	1.1	33	20	25	60	18
Minimum low season								12	1.4	42	25	32		
Maximum, with storage								100	11.4	340	200	260		
Low season, dry years								15	1.7	51	31	39		

Mr. Jackson estimates the available power of these three shoals during nine months of an ordinary year at 200, 150 to 200, and 120 horse-power, respectively. My estimates above given amount to 63, 39, and 49 horse-power during, say, the driest month of an ordinary year, and about 180, 120, and 150 horse-power during nine months. I do not know that Mr. Jackson's estimates are founded on gaugings, but my own are, of course, liable to many errors. Mr. Jackson states that at the factory they run full capacity (60 horse-power) all the time, with water always wasting some, which would indicate the above results, based on analogy, to be too small.

THE TIGER RIVER.

The next important tributary of the Broad is the Tiger, which enters it only 4½ miles above the mouth of the Enoree, and from the same side. It is formed in Spartanburgh county by the union of three forks, the north, middle, and south, whence it flows into Union, and at its lower extremity forms for a short distance the boundary between that county and Newberry. Of its headwaters, the south and the middle forks rise in Greenville county and drain respectively areas of 108 and 65 square miles, the latter uniting with the north fork, which rises in Spartanburgh county, and drains 41 square miles; the total drainage area of the middle and north forks at their junction with the south fork being 121 square miles. The length of the Tiger from the junction of its forks to its mouth is about 36 miles, measured in a straight line, and its total drainage area 720 square miles, almost exactly the same as that of the Enoree. The principal tributary of the stream is Fair Forest creek, which rises in Spartanburgh county and enters the Tiger in Union, about 15 miles from its mouth, after draining about 203 square miles. The Tiger is very similar in all respects to the Enoree, to which it flows nearly parallel, the distance between the two varying from 4 miles in their lower parts to 7 or 8 near their headwaters, the ridge between them being low. Their drainage-basins are also exactly similar in character, and the Tiger is also being gradually filled up and the shoals obliterated in places. The elevations of the three forks at their crossings with the Air-line railroad are as follows: South Tiger, 728 feet; Middle Tiger, 792 feet; North Tiger, 712 feet. The elevation of the mouth of the stream being about 285 feet, the fall is perhaps at the rate of 6 or 7 feet per mile, or about the same as that of the Enoree. The rainfall is the same as on the latter stream; and as regards accessibility, the same remarks are true regarding both.

On account of the silting up of the stream there are no shoals of importance for 30 or 40 miles from the mouth, the first worth mentioning being the site of "Hill's factory", situated about 18 miles from Spartanburgh, Laurens, and Union. Four miles below it is a fall of 10 feet used by a grist-mill, the available power at which place can be seen from the following table for Hill's factory. Between this point (called Burnt factory) and the mouth of the stream there were formerly 4 mills, all now abandoned on account of the filling up of the shoals.

At "Hill's factory" the fall continues for about three-fourths of a mile, but may be divided into three parts, the lower one with a fall of about 12 feet, the middle one with 15 to 16 feet, and the upper one with 12 to 15 feet (according to Mr. Hill). The width of the stream is about the same as that of the Enoree at Mountain shoals. The bed is rock, and the banks said to be favorable. The lower shoal has been used for a factory, but is now used for a grist-mill, and there were iron works on the middle shoal sixty or seventy years ago. The following table gives my estimate of the power:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Rainfall. Spring.	Summer.	Autumn.	Winter.	Year.	Flow per second.	Horse-power available, gross. 1 ft. fall.	40 ft. fall.	Remarks.
	Sq. miles.	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. feet.*			
Minimum	308	Perhaps 40 feet in all.	15	14	10	16	55	45	5.1	204	Fall according to Mr. Hill.
Minimum low season								60	6.8	272	
Maximum, with storage								330	37.5	1,500	
Low season, dry years								70	8.0	320	

Four miles above is a grist- and saw-mill (Nesbitt's), with a fall of 9 feet and a dam 5 feet high, subject to stoppage by backwater. The power available is probably about 70 horse-power in the low season of dry years, 86 in the low season of ordinary years, and over 200 during nine months in an ordinary year. The drainage area above is about 274 square miles. There are some powers above, below the junction of the forks, one of which is said to have a fall of 15 feet, and is not improved.

The North Tiger has one power below its junction with the Middle Tiger, used by a grist- and saw-mill (Ott's), with 14 feet fall. The dam does not extend entirely across, and is 3 feet high, the race being 200 feet long. The owner states that he has a fall of 36 feet in 300 yards, the bed and banks being rock; and it was very generally stated that this power is an excellent one. The drainage area above this place being about 112 square miles, I would estimate the power at about 2 horse-power per foot in the low season of dry years, 2½ in the low season of ordinary years, and perhaps 7 or 8 horse-power for nine months of ordinary years. It is said that there are three shoals not improved between this place and Nesbitt's, and the falls of the same are stated to be 10, 15, and 15 feet, the last below the junction of the south fork, and already referred to.

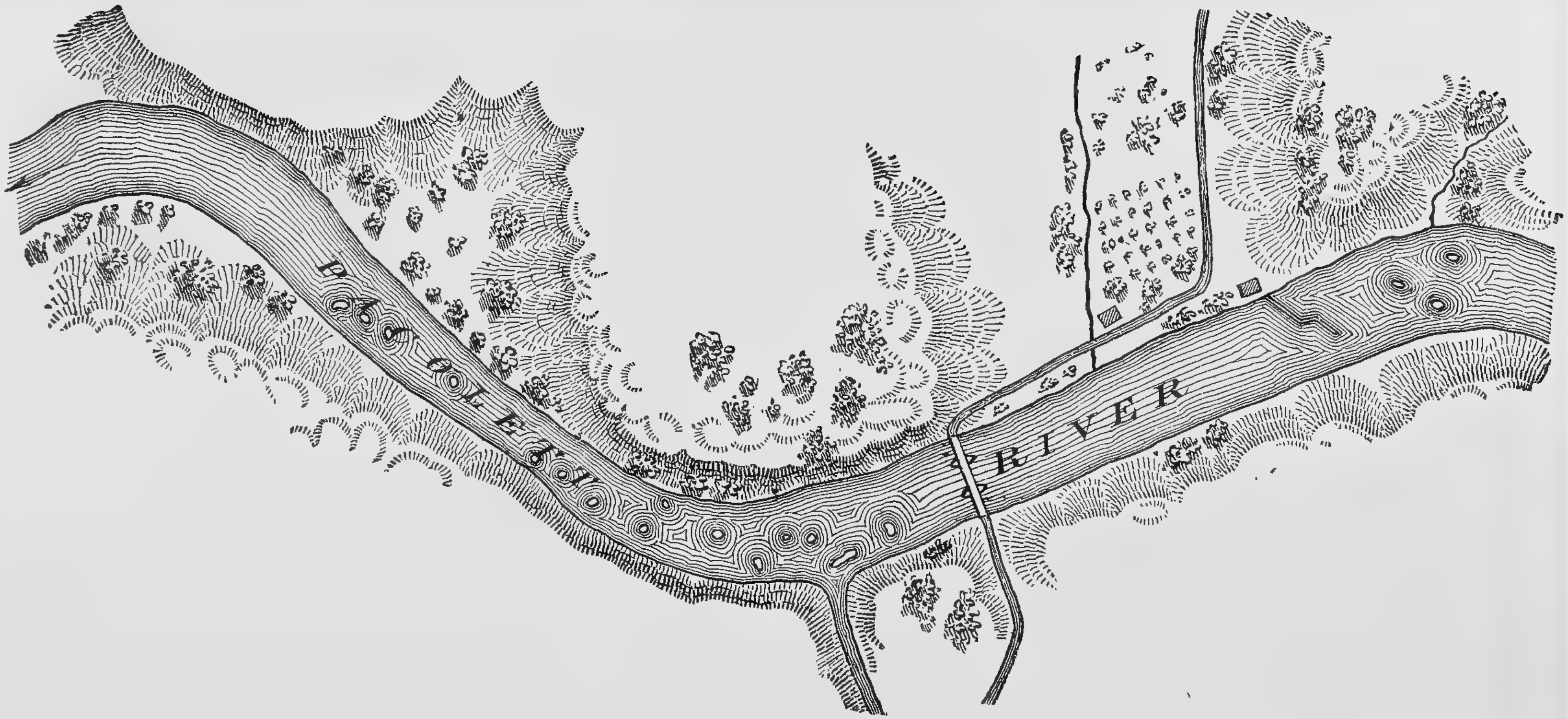
The North Tiger above the mouth of the Middle Tiger is so small a stream that it is not worth while to consider it in detail. There are several shoals and mills upon it, but the stream, even at its mouth, probably will not afford over 3 horse-power per foot for nine months in an ordinary year. The powers are excellent, although small, and are generally abrupt, with the best facilities for dams and buildings. There are some sites not used, one formerly used, belonging to Dr. Cleveland, with a fall of some 15 or 20 feet.

The Middle Tiger is also a small stream, its drainage area at its mouth being 65 square miles. It would therefore, in all probability, not afford over 5 or 6 horse-power per foot during nine months of an ordinary year. It has a number of shoals, where the stream pours over ledges of solid rock, falling from 10 to 20 feet in a short distance, and there are several grist-mills and a cotton factory on the stream. Dean's mill has a fall of 11 feet, and above it are 4 to 5 feet unimproved; the drainage area is about 50 square miles. At Ballinger's mills there is a fall of 14 feet; and at the Crawfordsville cotton factory a fall of 17½ feet is used, with 35 horse-power. There are three sites not used on the stream, of which the best is Penny shoal, one mile below Ballinger's mills, where there is a continuous fall for a distance of nearly a quarter of a mile over a layer of gneiss-rock, the total fall being about 35 feet. The banks are favorable for a canal and for building, but a high dam could not be erected at the head of the shoal, because it would reduce the fall at the mill above. The stream is from 100 to 150 feet wide. The drainage area above this shoal being about 50 square miles, the available power will probably not exceed 1.2 horse-power per foot in the low season of ordinary years (42 horse-power in all), and about 4 horse-power per foot during nine months of ordinary years (140 horse-power in all). This shoal is 2 miles from Wellford, on the Air-line railroad, and is owned by Dr. J. Jones, of that place. Below it, and a little above Crawfordsville, is a second unimproved shoal, said to be superior to the one at the latter place, it being equal in fall, and having better building facilities. Three miles below Crawfordsville is a third fall, not used, said to have a fall of 10 feet. I must once more state that the drainage areas I have calculated make no pretensions to accuracy, and I have more than once had occasion to notice great disagreements between those given by different maps. My estimates of power are likely to be in error one way or the other by fully 20 or 25 per cent.

The South Tiger is the largest of the three forks, and it resembles the other forks in all respects, and, like them, has a number of fine shoals, some used and some unimproved. It drains a total area of 108 square miles, and will therefore afford, in all probability, about 2 horse-power per foot in the low season of dry years, 2½ in the low season of ordinary years, and 6 or 7 for nine months of ordinary years. There is one cotton factory on the stream, with a fall of 17 feet, and several grist- and saw-mills. There is said to be one shoal, with a fall of about 10 feet, not used, not far from the mouth. Some of the shoals on this stream are being silted up.

Fair Forest creek, the principal tributary of the Tiger, flows within a mile or so of Spartanburgh, and within 5 miles of Union, and has a number of grist-mills. Being similar in character to the streams already described, it is necessary merely to describe the only important shoal on the stream, at present not utilized, viz, Murphy's shoal, about 5 miles from Union, and about an equal distance from the mouth of the stream. The fall is about 19 feet in a distance of 400, over a ledge of gneiss-rock; but the rapids continue below, the total fall amounting to about 27 feet in 1,000. Just above the falls the stream is 100 feet wide, and at the falls it is about 200 or 250 feet wide. The left bank is favorable for building, and the fall of 19 feet could be utilized very easily, and in fact 14 feet of it have been utilized until within a few months by a grist-mill and cotton-gin, with a low wing-dam about 300 feet long and 3 or 4 feet high and a wooden flume 150 feet in length. A high dam could not well be built without overflowing considerable bottom-land. The drainage area above this site being about 180 square miles, I have estimated the power in the following table:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*19 feet fall.*	*27 feet fall.*
Minimum	180	27	27	3.0	57	81
Minimum low season			36	4.0	76	108
Maximum, with storage			200	22.7	431	613
Low season, dry years			44	5.0	95	135


PACOLET RIVER

Hence in ordinary years, with 19 feet fall, about 110 horse-power could be obtained in the dry season, and over 300 during nine months.

The banks on the south side of the stream are high and rocky, so that the power can best be used on the other side, where the grist-mill was. The utilization of the total fall of 27 feet would not be so easy, the location not being so safe, on account of the presence of a bottom just below the main fall.

Less than a mile below this shoal is a small rift, with a fall of perhaps 6 feet in 600, with a favorable location on the south side. Between the two there are other shoals, which make up, with the one just referred to, a fall of 12 or 15 feet in a distance of three-eighths of a mile. This fall is available, and could best be utilized by building a dam about 8 feet in height, provided the bed should be found favorable. This place, however, is far inferior to Murphy's shoal.

On a little tributary to the Fair Forest river, about 5 miles from Spartanburgh, there is a perpendicular fall of 30 or 40 feet; but the stream is so small that the power is unimportant, though it is used by a small mill.

THE PACOLETT RIVER.

The next tributary of the Broad river which is worthy of special mention is the Pacolett river, which enters from the west in Union county, at a point about 75 miles above Columbia, and is one of the most important tributaries as regards water-power. It is formed by the union of two forks, the North Pacolett and the South Pacolett, the former rising in the southern part of Polk county, North Carolina, and the latter in the northern part of Greenville county, South Carolina, uniting in Spartanburgh county. The distance from the junction of these forks to the mouth of the river is about 37 miles in a straight line, and the total drainage area of the stream is about 475 square miles, of which the North Pacolett drains 80 square miles, the South Pacolett 82 square miles, and Lawson's fork, the other principal tributary, 82 square miles. The stream flows within 7 miles of Spartanburgh, Lawson's fork passing within 2 miles of that place.

The drainage-basin of the Pacolett river is mountainous in its upper part, and especially in that part drained by the North fork, which is a real mountain stream, tumbling down a narrow valley, from rock to rock, with a fall of 100 feet or over to the mile. The basin of the South fork, and of the main stream below the junction of the two, is very similar to that of the Tiger, or to that of the Enoree, except that it is more hilly and broken, especially toward the lower part, where there are fewer bottoms than near the foot of the mountains. The rainfall is about the same also. The elevation of the stream at the crossing of the Air-line railroad is 612 feet, and at its mouth about 400 feet; so that the fall between those points is at the rate of about 7 feet to the mile, or about the same as that of the Tiger and the Enoree. The stream is a succession of shoals, and affords considerable water-power; and it has one great advantage over the Tiger and the Enoree, viz, that it is easily accessible from the Air-line and the Spartanburgh and Union railroads.

The first shoal met with in ascending the river is Skull shoal, 4 miles from the mouth, but the fall is only 3 feet or so. It is to be remarked here that the Pacolett and the streams north of it suffer less from the silting up of shoals than the Tiger and the Enoree, perhaps due to the fact that the country is better wooded as the mountains are approached. The next shoal above Skull shoal is Grindall shoal, 14 miles from the mouth, with a fall of about 6 feet, used by a grist-mill. The next is Easterwood shoal, 17 miles from the mouth, mentioned by Mills as having a fall of 6½ feet in six chains; but it has filled up somewhat since his report, and is of no value. The first really important power on the stream is Trough shoal, the most notable fall on the river, 23 miles from its mouth, 12 miles from Spartanburgh, and 2 miles from Pacolett station, on the Spartanburgh and Union railroad. The total length of the shoal is nearly three-fourths of a mile, and the total fall in that distance 60 feet or thereabout, as ascertained by a pocket-level. At the upper end the stream is contracted for a distance of 100 feet or over between two vertical walls of rock to a width of from 10 to 15 feet, the depth being about 16 feet at ordinary stages of the water; but at high water these walls are overflowed, and the whole stream has a width of 200 or 300 feet. The bed of the stream is solid rock or bowlders for the entire length of the shoal, and the fall is distributed as follows, commencing at the head:

Twenty-two feet in 500, including the "trough"; width about 200 feet; banks on the right not bluffy, and favorable for building; on the left not so good.

Five and a half feet in 750, down to where the stream is crossed by a bridge; width, 200 feet. Bank on the right favorable; on the left rocky. This fall extends from the foot of the dam (a wooden wing-dam about 250 feet long and 4 feet high, extending in a broken line out into the stream) to the bridge, the dam supplying power to a saw- and grist-mill and cotton-gin, and having a fall of from 6 to 7 feet.

Five and a half feet in 350; a very steep and rocky bluff on both sides, especially on the right, and very difficult or impossible to canal along it.

Eleven feet in 500, and both banks are very rocky and steep. At the head of this distance a creek enters from the left.

Five and a half feet in 250, both banks being steep and rocky. It includes the narrowest part of the shoal below the trough, the stream being from 100 to 125 feet wide.

Five and a half feet in 750, the bank rocky on the right, except at the center of distance, where the hills recede, and the left bank is high and precipitous at the upper end, but low at the lower end. Width of stream at head, 150 feet; at foot, 200 feet.

Five and a half feet in 300, the right bank being very rocky and steep. This makes a total of about 60 feet.

The accompanying sketch, which makes no pretensions to accuracy, will make the location clearer.

From the above, it is clear that the utilization of the entire fall at one place would be impracticable, except at great expense. At the head, however, a fall of 20 feet could be used very easily, with no dam of importance, and with a favorable site for building on the south side. If the fall below were to be used, it could probably best be done by a dam near the middle of the shoal, and perhaps 15 to 20 feet high, which could be put in without doing any damage by overflowing. A canal one-quarter of a mile long would give a fall of perhaps 30 feet at the foot of the shoal. The drainage area and the estimated power for this place are given in the following table:

Table of power at Trough shoals.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Rainfall.					Flow per second.	Horse-power available, gross.			Utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.					Horse-power, net.	Fall.
	Sq. miles.	Feet.	In.	In.	In.	In.	In.	Cu. ft.	1 foot.	20 feet.	30 feet.		Feet.
Minimum	380	60	15	14	10	16	55	62	7.0	140	210	25 ±	6
Minimum low season								88	10.0	200	300		
Maximum, with storage								420	47.7	950	1,430		
Low season, dry years								100	11.4	230	350		

This power is one of the best in the vicinity. As before stated, it is used now only by a small grist-mill. Building-stone can be had in the neighborhood, and the railroad is only two miles distant.

One mile above Trough shoals is Brown's mill, where there is said to be a fall of some 14 feet, and two and a half miles beyond is Hammett's mill, said to have a fall of 8 or 10 feet. This is above the mouth of Lawson's fork, and the drainage area is not much greater than that above Clifton. Just below the mouth of Lawson's fork is the Crocker Ford shoal (fall not known). Two and a half miles above it, and above Hammett's mill, is another shoal, at Thompson's ford, with a fall of perhaps 5 or 6 feet; and two miles further up is a third shoal, said to have a fall of about 10 feet. One mile above, and 30 miles from the mouth of the river, is Hurricane shoal, formerly occupied by iron works, but now the site of the Clifton cotton factory. This shoal is 7 miles from Spartanburgh, and only a mile or two from the Air-line railroad. The fall is 22 feet, and the estimated power is as follows:

Table of power at Clifton factory.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Remarks.
	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	22 feet fall.	
Minimum	220	22	33	3.7	80	The estimate of drainage area is particularly liable to error in the case of this stream.
Minimum low season			44	5.0	110	
Maximum, with storage			250	28.4	625	
Low season, dry years			53	6.0	130	

According to the estimate, in ordinary years 160 horse-power may be expected in the dry season, and 400 or over for nine months.

Two miles above Clifton is a fall of perhaps 8 feet, not improved, called the Lindner shoal. This is the last shoal on the main stream.

Mills gives the following shoals above the mouth of Lawson's fork: 3 miles from junction, 12 feet in 10 chains (this is probably Hammett's Mill shoal); 2 miles above, 10 feet in 3 chains (this is probably Hammett's upper shoal); a mile above, Hurricane shoal, 16 feet in 40 chains; 5 miles further up, 8 feet in 4 chains (this is perhaps the Lindner shoal). The chain referred to is probably 66 feet.

The South fork has only small saw- or grist-mills, and no large powers so far as could be learned. The North fork has a very large fall in its upper part, and below the mountains is a grist-mill with 12 feet fall, and a cotton factory with 12 feet fall. Both streams are of about the same size, draining about 80 square miles each, and will probably afford at their mouths 2 horse-power per foot fall in the dry season of ordinary years and 5 or 6 horse-power during nine months. The Spartanburgh and Ashville railroad follows the North fork for some miles in the mountains, where the stream is a roaring mountain torrent. There are numerous sites for small mills here, and there is one saw- and grist-mill, with a fall of 34 feet and scarcely any dam, and a race a quarter of a mile long.

Lawson's fork, which enters the Pacolett several miles below Clifton, has a drainage area of about 82 square miles, and will probably give 2 horse-power per foot during the dry season of ordinary years and 6 horse-power during nine months, according to my estimates. There are several falls on it: the first, just below Glendale, of 15 feet or so, not used, giving 90 horse-power most of the time; the second, at Glendale, 6 miles from Spartanburgh, used by the cotton factory of D. E. Converse & Co. The dam is of rock, rebuilt in 1879 at a cost of $1,200, and is 300 feet long

and 4 feet high. The head-race is 700 feet long, and the fall 35 feet, 200 horse-power being utilized by storing the water at night in a natural pond half a mile above, the factory being run 12 hours. The pond above is formed by a natural dam, which crosses the stream. This dam has been blasted through at one place for the gates, through which the water is drawn down during the day. The reservoir is half a mile long, 150 feet wide, and 5 feet deep, and is large enough to store all the water at low-water stage. This natural dam affords a fall of 12 feet in all, which is now unimproved, but would afford one-third the power at Glendale. According to my estimates, the gross power available at Glendale would be 210 horse-power for nine months of an ordinary year for the natural flow of the stream and 70 horse-power for the low season, or 140, with storage, during 12 hours. The shipping-point for Glendale is Spartanburgh.

Above Glendale there are several small grist-mills and one cotton factory on the stream, some with good shoals, but the stream is small.

Thicketty creek, a tributary of Broad river, enters from the west about 6 miles above the mouth of the Pacolett. It drains an area of 100 square miles, and has no large falls, so far as I could learn.

Bullock's creek and King's creek, both from the east, drain about 72 square miles each, and offer no large powers.

Buffalo creek, which rises in North Carolina and joins the Broad in York county, South Carolina, draining an area of 178 square miles, is a tributary of some importance. It has a considerable fall, and is utilized by a number of grist- and saw-mills and one paper-mill. It will probably afford at its mouth about 5½ horse-power per foot fall in the low season of ordinary years, and 15 or over during nine months. The stream is only 15 feet wide at its mouth.

FIRST BROAD RIVER.

This tributary rises in the extreme northern part of Cleaveland and Rutherford counties, North Carolina, and flows south through the former, passing within three miles of Shelby, joining the Broad a mile below Palmer's shoal. It drains an area of 302 square miles, and its fall from the crossing of the projected railroad from Shelby to Rutherfordton is about 105 feet, or at the rate of 8 feet or more per mile. The rainfall is the same as on the Pacolett and Tiger. The width of the stream at its mouth is 90 feet.

The first power on the river is Chambers' grist-mill, with a fall of 9 feet, though 15 feet are said to be available. The stream is almost as large here as at its mouth, and will probably afford 7 or 8 horse-power per foot fall in the low season of dry years, 9 or 10 in the low season of ordinary years, and 20 or 25 for nine months.

Above come two small grist-mills, and then a third (Loutze's), where there is said to be 12 feet fall available. The next important power is at Double shoals, at the cotton factory of E. A. Morgan & Co., a fall of 8 feet and 30 or 40 horse-power being used. It is said that double this amount of fall could be obtained with a canal 400 yards long. The place is some 15 miles from the mouth of the stream, and the drainage area is perhaps three-fifths what it is at the mouth. There are other mills above, and on a tributary (Knob creek) is the cotton factory of Schenck, Ramsour & Co., with 15 feet fall, and about 35 horse-power.

SECOND BROAD RIVER.

This river, the next tributary worth mentioning, rises in McDowell county, and flows through Rutherford county, draining an area of 193 square miles. It is a small stream, only 30 feet wide at its mouth, but there are several good powers on it, viz:

Tumbling shoal, 3 miles from the mouth, not now utilized, is the first, and it is said that a fall of 15 feet could be obtained, with good building-sites, in a distance of 200 yards. The stream would probably give from 4½ to 5 horse-power per foot in low seasons of dry years.

High shoal, one mile above, is said to be the best water-power in Rutherford county. It is not now utilized, but was formerly used for iron works. The fall is stated to be 29 feet in 400 yards, over a solid rock bed, all of which is available, with good building-sites. The stream is about as large as at Tumbling shoal, and will perhaps give 6 horse-power per foot in dry seasons of ordinary years, and perhaps 15 or more during nine months.

The "Burnt factory", 2 miles above, is the next site—a very good one, now used for a saw- and grist-mill, with a crib-dam 300 feet long, 9 or 10 feet high, a race 100 feet long, and a fall of 14 feet, capable of being increased to 16.

Farther up the river are other shoals, but they are of no great consequence, although in its upper parts the fall of the stream is very great.

Shelby is the nearest railroad point to all of the shoals mentioned on the Broad rivers, being 16 miles from High shoal and Tumbling shoal and 8 miles from Double shoals. There are numerous other water-powers in the vicinity on smaller streams; thus on Brushy creek, a tributary of the First Broad, there is within 2 miles of Shelby a fall of 36 feet in 600 yards, not improved, said to be capable of affording 50 horse-power in dry seasons; and on Muddy fork, a tributary to the Buffalo creek, there is an unimproved fall of 20 feet in 100 yards about a mile from its mouth, said to be good for 40 horse-power in dry weather. All these streams have, as a rule, rock beds and good banks, which are not often overflowed. They are subject to heavy but short freshets. The soil in all this region is clay and loam.

The projected railroad to Rutherfordton, the grading for which was done long ago, will pass nearer to some of the powers which have been mentioned; for instance, within 3 miles of High shoal.

GREEN RIVER.

This, the last important tributary of the Broad, rises in the mountains of Henderson county, and flows a little north of east into Polk county, where it joins the Broad. The upper part of its course lies in a narrow valley, not over 4 miles wide for 20 miles from the head of the stream, but below that the basin is much wider. The length of the stream in a straight line is about 36 miles, and its drainage area 198 square miles. It has a rapid fall, and considerable power is available, though very little is used. The bed is rock, and the banks in some places are nearly vertical rock walls, while at others the river winds through fertile bottoms, subject at times, though not extensively, to overflow, these bottoms being specially frequent in the lower part of its course. The stream is very inaccessible, being crossed by only one railroad—the Spartanburgh and Asheville—about 16 miles from its head. The stream is about 75 or 100 feet wide where this road crosses it, and 90 feet wide at its mouth.

I obtained information regarding three shoals on the stream, but on account of the rapid fall there are doubtless other places where power could be obtained by damming. The lowest point is at Green River cove, where there is said to be a considerable fall, not utilized, extending over some distance. This site is some distance from the railroad, and not easily accessible. Pott shoal, which is just below the railroad-crossing, is much more favorable, and is said to be the best site on the river. The falls commence just below the bridge, and continue for some distance, the fall being very rapid, with now and then an abrupt fall of several feet. The bed is solid rock, and the banks generally high; but near the foot of the shoal there is said to be a very good building-site. The shoal takes its name from a number of curiously worn-out holes in the rock forming the bed of the stream, almost circular, and looking very much like large auger holes.

About two miles above the railroad, and therefore not so favorably located as Pott shoal, are the falls of the Green river, the third site above referred to, and the only one I visited in person. The fall is about 30 feet in 100, preceded by rapids for three-eighths of a mile, making a total fall of over 45 feet. The banks are rocky and very steep, so that building facilities are not very good. The drainage area above this place is about 67 square miles, and the available power would perhaps be 1 horse-power or a little over per foot in the low season of dry years, and $3\frac{1}{2}$ or 4 horse-power for nine months of an ordinary year. The building facilities at Pott shoal are said to be much better than at these falls, and the fall is also said to be greater.

THE SALUDA RIVER.

The Saluda is formed on the boundary between Pickens and Greenville counties, South Carolina, by the union of its north, south, and middle forks, whence it flows southeast, forming the boundary-line between Anderson, Abbeville, and Edgefield counties on its right, and Greenville, Laurens, and Newberry counties on its left, and after passing through Lexington county unites with the Broad to form the Congaree. The length of the stream, in a straight line, is about 110 miles, and its drainage area 2,350 square miles. All its important tributaries enter from the north side, viz: Bush river, Little river, and Reedy river. The general character of the Saluda is similar to that of the Enoree river and other tributaries of the Broad. The three forks rise in the mountains, the north fork very near to the North Carolina line and very near to the sources of the Pacolett, and all three are mountain streams. Down as far as the lower border of Anderson county the country is broken, and the banks of the stream are generally high, with few bottoms; below that the country is more open, and there are considerable areas of bottom-land subject to overflow. The facilities for artificial reservoirs are said to be rather poor, as on all the tributaries of the Broad, the fall of the streams being so rapid. The bed is rock, and the banks in places of the same material, and in other places alluvial. The rainfall in the basin is about 51 inches (see p. 121). The following table will show approximately the declivity of the stream:

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Mouth	0	148			
			60	235	3.9
Crossing of Greenville and Columbia railroad	60	383			
			65	366	5.6
Crossing of Greenville and Columbia railroad	125	749			
			10	60	6.0
Crossing of Atlanta and Charlotte Air-line railroad	135	809			

The stream is accessible from the Greenville and Columbia railroad and from the Air-line railroad, as will be seen from the map.

The water-powers met with in ascending the stream will now be described:

At Beard's falls, 2 miles above Columbia, is the factory of the Saluda Manufacturing Company. The dam is of stone, 900 feet long and 9 feet high, and at the factory the fall is from 14 to 16 feet, the race being 200 feet long. The

power utilized is 150 horse-power, with always a waste of water. According to what has been said regarding the flow of the Saluda, the power at this place is estimated as follows:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*16 feet fall.*
Minimum	2, 350	16	550	62. 5	1, 000
Minimum low season			700	79. 5	1, 275
Maximum, with storage			2, 100	238. 6	3, 800
Low season, dry years			825	93. 7	1, 500

The Saluda river was made navigable many years ago by the state, and three canals were constructed, the lowest one being around Beard's falls. The canal was 2½ miles long, and had 5 locks, with 34 feet lift together, covering the fall of the river between its mouth (where there was a dam across the Broad, in the pool of which the boats were floated over to the Columbia canal) and the head of Lorick's falls, a mile and a half above the Saluda factory. At these falls there is a natural fall in the river of about 6 feet, and their head is 27 feet above the mouth of the river, according to a recent survey, from which it follows that there must have been a dam at the head nearly 10 feet high. The available power at the mouth of the Saluda may therefore be considered as that due to a fall of from 30 to 34 feet, and it is said that the old canal could be put in order without much difficulty.

The next site above Lorick's falls is above the mouth of Twelve-Mile creek, at Dreher's canal, the second state canal, which was a mile long, and had 4 locks, with a total lift of 21 feet.* The canal was on the north side, and the power is used now to run a grist- and saw-mill and a cotton-gin, using falls of less than 10 feet, the only dam existing being a rough stone wing-dam. This is an excellent site, and a fall of 20 feet could probably be rendered available, or 10 feet with a canal only 300 yards long. The place is about 6 miles from Lexington, which is the nearest railroad point. The drainage area above being about 2,200 square miles, the available power may be estimated for 20 feet fall, as in the table on page 121.

Three miles above this there was once, though not now, a mill. The next power is at Wise's ferry, known as Hyler's shoal. The total fall is not known, but a fall of 5 feet is utilized by a grist-mill near the head. Mills gives a fall near Wise's ferry of 17 feet, but whether there is a fall there now I cannot say.

Above that is a small shoal known as Kelly's, and then a shoal at Hiller's ferry, with a mill on each side of the river, using, however, falls of only a few feet. The available fall at this place I am unable to state. Mills mentions several shoals above Wise's ferry, in Lexington county, viz: Hunter's ferry (5½ feet), shoal (3½ feet), Snellgrove's island (9 feet), Manning's island, or Simon's ferry (15 feet, and a little above 15 feet additional), Domick's mill (15 feet); making in all, in Lexington county, a fall in the river of over 135 feet in a distance of perhaps 25 to 30 miles. For want of accurate data I have not tabulated these powers, but it is evident that the river offers a large amount of power in this distance. Above Hiller's ferry the next large fall is said to be at Calk's ferry, probably called Simon's ferry by Mills. There is a mill at this place using a fall of 5 feet, and, according to all that could be learned, the fall is one of the best on this part of the river.

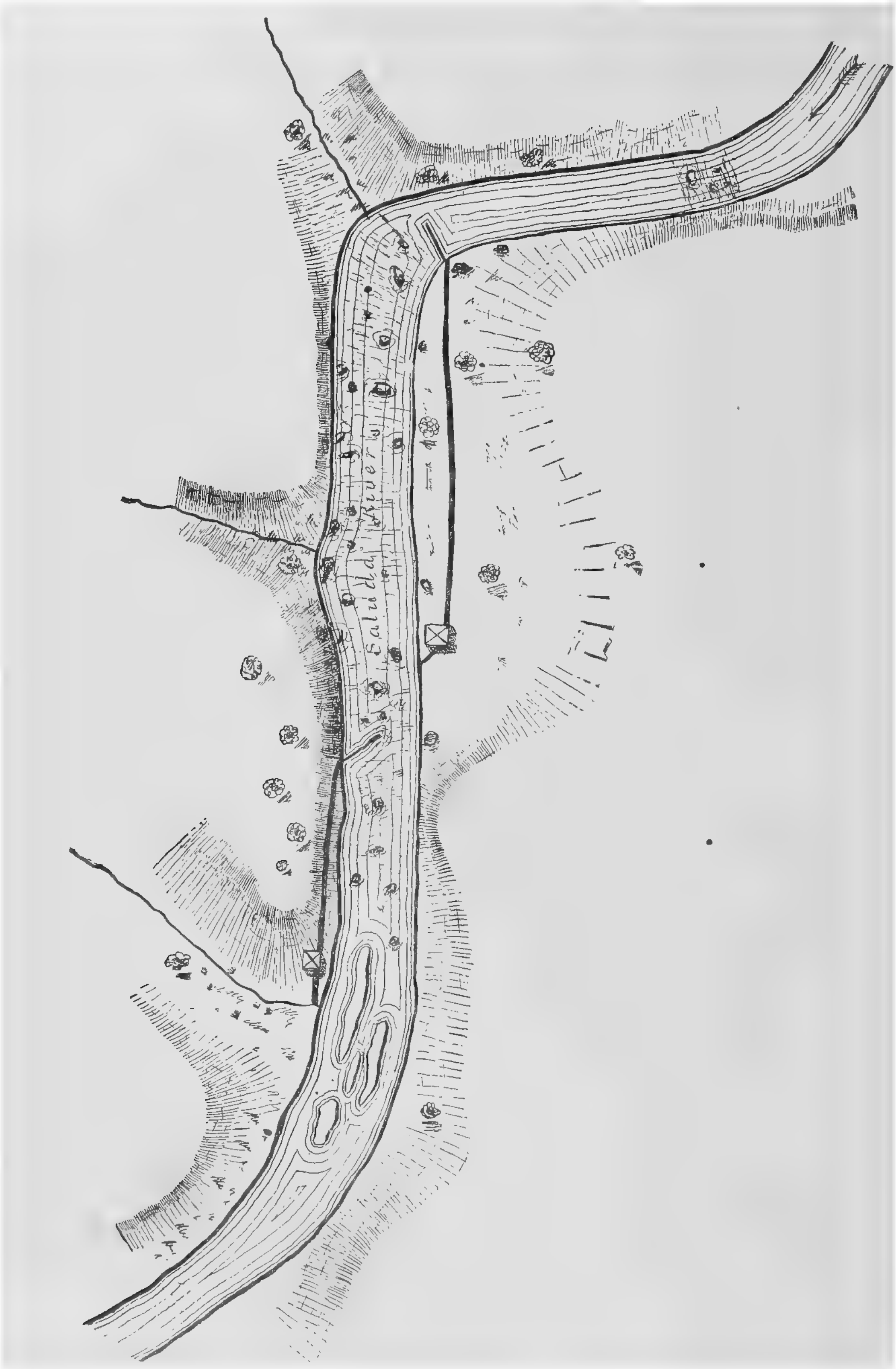
The next site is at McNary's ferry, where there is a mill using a fall of 11 feet, with a dam 4 feet high and a race 100 feet long. It is said to be a fine power, with only a small fraction utilized.

There was formerly a mill a mile or two below the mouth of the Little Saluda, but the next site of importance is 8 miles further up, at Perkins' ford. This shoal is said to be the best in Newberry and Edgefield counties, and is altogether unimproved. The banks are said to be favorable for building, and the fall was variously stated at from 5 to 10 feet in half a mile.

Bauknight's mill, one and a half miles above, is said to be the site of the third canal on the river, which had one lock, with a lift of 6 feet. The canal is on the north side, while the mill is on the other. Above this there are several small shoals and small mills. The river seems to be quite sluggish through this part of its course from Perkins' ford up, and the banks are said to be troublesome, and to wash out often at the dams. The next important power, and the most important on this part of the stream, is at Ware's mill, or the Great falls, above the mouth of Reedy river, and about 12 miles from Hodges, the nearest railroad point. It is shown in the following sketch:

* All statements regarding these canals are from Mills.

Sketch of the Saluda river at the Great falls, South Carolina.



The shoal is a mile long, and the fall is, in all, about 45 feet. At the head is a wing-dam on the left bank, and a race half a mile long gives a fall of 21 feet at Gaines' saw-mill. About 300 yards below the tail-race is a second wing-dam on the right bank, and a race 300 yards long gives a fall of 20 feet at Hart's grist- and saw-mill. The width of the river is about 400 feet opposite Hart's dam, and 200 feet below the shoals. The total fall could not be used at Hart's mill without a very expensive canal around bluffs. It could, however, be used on the left bank, this side being much more favorable. The most convenient location, however, is on the left bank, just below Gaines' mill, and by building a dam where Gaines' wing-dam is now, making it 10 feet high, or sufficient to back up

over a shoal about one-fourth of a mile above, a fall of 35 feet could be utilized with a race half a mile long. The bed of the stream is solid rock, and the facilities for the utilization of power are, in all respects, excellent. This is one of the best powers on the river. It is to be mentioned that a mile below the foot of the shoal is Robertson's shoal, with a fall of 3 or 4 feet, not of value for power.

Three or four miles above Ware's is Mattox's mill, 9 miles below Honea Path. It is not an important power, the fall being said to be only 4 or 5 feet. The next important power is Erwin's mill, a few miles from Honea Path, and at the lower border of Abbeville county. The river is divided by two islands, the total width being about 200 yards. Across one of the arms is a dam 300 feet long and 3 feet high, giving, with a race 150 feet long, a fall of 8 feet, capable of being increased to 10 feet, it is said, by going farther down.

Above Erwin's come several small shoals—Harper's, Kay's, and Gambrell's—not of much consequence, except Harper's, where it is said that a fall of 8 feet could be obtained. The next shoal is opposite Belton, used by Poore & Cox's mills, with a fall of about 8 feet, not capable of being increased, and not of importance for manufacturing. Some distance above is a ledge known as Hamilton Ford shoal, with a fall of 4 feet, which could be increased to 10 feet—a good location, and near the railroad.

Half a mile above is Holland's Ford shoal, with a fall of 7 feet in 300 yards, which is not improved. A canal 200 yards long would be necessary, and would not be expensive. It is one and a quarter miles from the railroad, and the amount of water is about the same as at Piedmont (see beyond). A dam could be built 8 feet high, giving a fall of 15 feet. Half a mile farther up is Blackburn Island shoal, not improved, with a fall of 6 feet in 100 yards, not capable of being increased to above 10 feet without backing over the shoals above. A canal would be difficult to build on account of a high rock bluff. Three-fourths of a mile above are the Tripp shoals, not improved, with a fall of 8 feet in 300 yards, capable of being increased to 16 feet without backing up to more than within 5 feet of the fall above. The shoal is of solid rock, and a canal would not be difficult. The place is a favorable one, situated one and a half miles from Williamston, on the railroad.

One mile above, at Wilson's ferry, the Pelzer Manufacturing Company is putting up a cotton factory. The dam is of granite, in cement, 250 feet long and 15 feet high, with a race of 200 feet, and a fall used of 21 feet at low water. The mill is building for 13,000 spindles, and is expected to be in operation by December 1, 1881. The site is a very favorable one, one and a half miles from Williamston, on the railroad, and half a mile from the nearest railroad point, from which a siding is to be run.

Six miles above is the factory of the Piedmont Manufacturing Company, but between this and the Pelzer mill is the Allen shoal, not used, with a natural fall of 14 feet in 250 yards, capable of being increased to 18 feet without interfering with the Piedmont factory. It is the most imposing fall on this part of the river, and is in all respects a very fine site. Bed and banks are favorable, and the place is located only a quarter of a mile from the railroad.

The Piedmont factory, one of the most important cotton-mills of the state, is 2 miles above the Allen shoal. The dam is of wood and stone, built in a curve on a solid rock foundation, and is 270 feet long and 7½ feet high. It was first built in 1873, and raised in 1879. A head-race 250 feet long, cut through stone, gives a fall of 16 feet at the wheel. The power used is stated at 500 horse-power, which it is said can be obtained during eleven months, and 400 during the remaining month. In addition to this, about 20 horse-power is used by a saw- and grist-mill, with a fall of 10 feet. The capacity of this factory is at present being increased, and it is intended to use 800 horse-power, which it is expected to obtain during eleven months, and 700 the other month; the fall is at the same time increased to 20 feet by raising the dam to a height of 11½ feet. No steam-power is used. It is to be remarked that here, as well as at all the other sites on this part of the Saluda, the conformation of the banks is such that large ponds are not formed, and the natural flow of the stream is all that can be utilized. When the mills are not running water flows over the dam.

The drainage area of the stream above Piedmont was measured from the map and found to be about 380 square miles. The rainfall is 56 inches. Reasoning by analogy, I would therefore estimate the power as follows:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*
Minimum	380	20	70	8.0	160
Minimum low season			105	12.0	240
Maximum, with storage			425	48.3	970
Low season, dry years			125	14.2	284

I have made these estimates larger than those for Mountain shoal on the Enoree, and others in the neighborhood, because the Saluda extends farther into the mountains, and the rainfall is greater. I have even made them large in proportion to the other estimates for the Saluda, and the latter estimates may be, in fact, too small.*

* Since the above was written, I have observed that in the statistics of cotton-mills for the state of South Carolina, according to the present census, the power used at the Piedmont factory is stated at 320 horse-power.

According to the above table, in the low season of ordinary years about 350 horse-power could be depended upon, and probably 800 to 1,000 during nine months. The Piedmont factory has been nominally using over 400 horse-power at all times. I incline to think that the power actually used is hardly so large, but the result must once more show that the estimates of power given, although as accurate as I am able to make them with the data at hand, must be taken as approximations only.

Above Piedmont is a small shoal, where there was once a grist-mill; but the fall is only 4 or 5 feet, and it is of no importance.

The next is the Blasingame shoal, 5 miles from Greenville. It is said to have considerable fall, but to be hard to develop.

Harrison shoal, 6 miles from Greenville, which has never been used, is the next. It is said to have a small fall, and to be of no importance for manufacturing.

The last shoal on the main stream is at Farr's mills, also 6 miles from Greenville. It is utilized by a saw- and grist-mill, with a fall of 7 feet, using only 20 or 30 horse-power probably. The dam is of wood and stone, 300 feet long and 5 feet high, and the head-race is 200 feet long. It is said that the fall could be increased to some extent.

Summary of power on the Saluda river.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horse-power available, gross.*				Utilized.		Percentage of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*							*Feet.*		
Saluda factory	1.0	2,350	13	13	9	16	51	16		1,000	1,275	3,800	1,500	150	16	20	Dam, 9 feet.
Mouth of Saluda	2.5	2,350	13	13	9	16	51	34	2.5 miles.	2,100	2,700	8,100	3,200	150	16	10	
Dreher's canal	10.0	2,200	14	13	10	16	53	20	1 mile	1,150	1,500	4,400	1,750	50—	3–9	5—	
Hyler's shoal	14.0	2,200	14	14	10	16	54	17 (?)						15	5		
Kelly's shoal								5–6 (?)						0	0	0	
Heller's ferry								9 (?)						50—			
Calk's ferry								30 (?)						30—	5		
McNary's ferry								15 (?)							11		
Summers' mill														0	0	0	
Perkins' ford								5–10 (?)						0	0	0	
Bauknight's mill								6						Small	Small		
Great falls	65±	635	15	14	10	16	55	55	1.25 mile	800	1,000	4,000	1,200	50—	39	5	
Mattox's mill	69±	600						4–5		60±	75±	300±	90±				
Erwin's mill		523						8–10		120±	150±	600±	175±				
Harper's shoal								8–10 (?)						0	0	0	
Poore & Cox's mill								8									
Hamilton ford shoal								†4						0	0	0	
Holland's ford shoal								†7	900 feet					0	0	0	
Blackburn's Island shoal								†6	300 feet					0	0	0	
Tripp shoal								†8	900 feet					0	0	0	
Pelzer Manufacturing Company.		400	15	14	10	16	55	21						(‡)	(‡)	(‡)	Dam, 15 feet.
Allen shoal		400						†14	600 feet					0	0	0	
Piedmont Manufacturing Company.		380						20		100	240	970	284	(?)	20	(?)	Dam, 11.5 feet.
Small shoal								4–5						0	0	0	
Blasingame shoal														0	0	0	
Harrison shoal														0		0	
Farr's mills		275												20–30	7		Dam, 5 feet,

* See pages 18 to 21. † Without dam. ‡ Not yet running.

TRIBUTARIES OF THE SALUDA RIVER.

Twelve-Mile creek is the first stream worth mentioning in this connection. It enters the Saluda from the south a few miles above the Saluda factory, and drains an area of 93 square miles, entirely in Lexington county. It is to some extent a sand-hill stream, not very variable in flow, and it is utilized for a number of saw- and grist-mills, with falls of from 7 to 12 feet. The stream is said by those acquainted with it to afford near its mouth about 5 horse-power per foot most of the time. It flows by the town of Lexington, in the neighborhood of which there are two sites not utilized, said to be the only ones of any importance on the stream. Close by the town is a grist-mill, with a fall of 10 or 12 feet, and just below it is a fall of about 14 feet in half a mile. Just above the mill is the site of the old Laurel Fall factory, now used by a grist-mill, which, however, only utilizes a small part of the power. The first site referred to is a good one, and could be combined with the one occupied by the mill, giving a total fall of between 20 and 30 feet. The stream here is not over half as large as it is at its mouth.

Little Saluda creek, from the south, is the next tributary of note. It drains about 297 square miles, and joins the main stream at Wise's ferry. Its water-power, however, is not of much importance, and its flow is quite variable. There are a few small grist-mills on the stream and its tributaries, but it is not favorable for power.

Bush river, which rises in Laurens county, and enters the Saluda just below Perkins' ford, in Newberry county, drains an area of 105 square miles, and has considerable fall and some sites not used, but the powers are all small. The stream is quite variable in flow, and the mills have to stop in summer.

Little river, which rises in Laurens county and flows nearly parallel to Bush river, drains about 220 square miles, but is sluggish, and has no power of importance.

The only other tributary below the forks worth mentioning is Reedy river, which rises in Greenville county, flows southeast into Laurens, and enters the Saluda several miles below the Great falls, after draining an area of about 386 square miles. The length of the stream, measured in a straight line, is about 50 miles, and it receives one tributary worth mentioning, Reaburn's creek, which drains 105 square miles. The river flows through the town of Greenville, and offers a large amount of power, being shoaly for its entire length. The map shows the form and dimensions of the drainage-basin. The rainfall is about 53 inches on the entire basin: 15 in spring, 13 in summer, 9 in autumn, and 16 in winter. The fall of the stream is considerable, and much greater than that of the Saluda, its elevation at Greenville, at the crossing of the Air-line railroad, being 929 feet, while that of the Saluda is 809 feet, and that of the Enoree 842 feet, at the points where the same road crosses them. The bed of the stream is rocky, and the banks in some places high and rocky, and in others low and alluvial. It is said that the bottoms on the Reedy river are more extensive than on the Saluda above the junction of the two, but the fall of the stream is so rapid that they are not often overflowed. The stream is not very accessible in some parts, the nearest railroad points being Greenville and Laurens, as will be seen from the map.

The shoals and mills on the streams are as follows, in their order ascending:

Washington's mill, grist and flour, with a small fall of 4½ feet or so. I would estimate the flow and power of the stream at its mouth as in the following table:

State of flow (see pages 18 to 21).	Drainage area.	Flow per second.	Horse-power, gross.
	Sq. miles.	*Cubic feet.*	*Per foot.*
Minimum	386	62	7.0
Minimum low season		82	9.4
Maximum, with storage		400	45.4
Low season, dry years		97	11.0

This mill, however, is probably above the mouth of Reaburn's creek, which enters Reedy river about 3 miles above its mouth, so that the stream is considerably smaller than at its mouth.

Next comes a grist-mill with 5½ feet fall; then a shoal not used, said to have a fall of about the same amount; then Boyd's shoal, used by a grist- and saw-mill with about 8 feet fall; then a long shoal, 2 or 3 miles long, not improved, said to be a good site, and once used by a small mill.

Then comes Tumbling shoal, about 16 miles from the mouth of the stream, 12 miles from Laurens, and 27 miles below Greenville. The shoal is short, and the fall amounts to 10 feet in 75. Here is a grist-mill using a fall of 10 feet and about 50 horse-power. The drainage area above the place is about 198 square miles, and I would estimate the gross power at about 34 horse-power (minimum), 45 horse-power (minimum low season), 53 horse-power (low season, dry years), and 60 to 70 horse-power during the low season of ordinary years. There is little storage during the night. The present mill uses all the power in dry seasons.

The next shoal is Cedar falls, though below it there used to be a tannery and grist-mill using a small fall. The fall at Cedar falls was stated at about 20 feet, of which 14 or 16 feet are used by a grist- and saw-mill and a cotton factory. The power used I do not know. There is no dam at all, and the mills are on both sides of the stream. The drainage area above this place is about 150 square miles.

One mile above it is Fork shoal, at the mouth of Reedy Fork creek, and about 16 miles from Greenville. There is a dam across both streams; that across the creek is 110 feet by 3, ponds over 10 acres, and at one end of it is situated the cotton-mill, using 20 feet fall and 40 horse-power, which can be obtained during about ten months, there being no waste in summer, except at night; that across the river is 125 feet by 2, and at one end of it is the grist-mill, with a fall of 7 feet, and using about 25 horse-power. The drainage area above this shoal is about 140 square miles.

It will be sufficient to mention simply the other shoals and mills, with one or two exceptions:

Harrison's grist-mill, about 10 feet fall.

Houff's mill (grist and saw), 10 feet fall.

Log shoal, 14 feet fall, with a 2-foot dam; used by a saw- and grist-mill.

Ashmore's grist-mill, 10 feet fall.

Linderman shoal, not used; small fall.

Reedy River Manufacturing Company, one and a half miles above. The dam is of wood, 225 by 5 feet, the fall 22 feet, and 125 horse-power is used during ten months and 100 horse-power the rest of the time. The drainage area is 87 square miles, and I would therefore estimate the power at about the same as on the Enoree at Pelham (see page 111).

Jones' paper-mill and saw-mill, 11½ feet fall; 50 horse-power during twelve months.

Parkins' grist-mill, 11 feet fall; said to be capable of increase by raising the dam.

Greene shoal, not used; very small—valueless.

Saw-mill shoal, not used; 8 or 9 feet fall.

Camperdown mills, at Greenville. The fall here is the most important on the stream, amounting to 64 feet in 500 yards, over a layer of gneiss-rock. The fall is used in two parts. The upper part is used on the left bank by Camperdown mill No. 2, and on the right bank by a machine-shop and box-factory, both using a fall of 32 feet. The dam is of timber bolted to the rock, 60 feet long and 3 feet high, making scarcely any pond; the race is 325 feet long, and the power used about 245 horse-power, which, however, can only be obtained for six months of the year. The factory uses 225 horse-power. The lower fall of 32 feet is used on the right bank by the Camperdown mill No. 1, with a triangular wooden frame dam 105 feet long and 14 feet high, bolted to the rock and planked over, and built in 1875 at a cost of $1,000. It ponds the water up to the tail-race of the upper factory, about 300 yards, and the head-race is 165 feet long. The power used is 160 horse-power, which can be obtained nine months of the year. This mill uses steam-power in dry seasons to the extent of 160 horse-power, while the upper mill uses up to 200 horse-power steam, the machine-shop using none.

Just above the upper mill is Cox & Markley's carriage factory, using about 12 horse-power, with a fall of 8 feet and a 4-foot dam, and utilizing all the water during the day-time in dry weather. The ponds are not large enough to store the water during the night, but just above the railroad crossing in Greenville there is said to be a good site for a storage-reservoir, where a 14-foot dam would flow 800 to 1,000 acres, allowing the power at the mills below to be increased to a considerable extent.

The drainage area of the stream above Greenville is only 44 square miles, and there are no falls above. It is evident that for such a small stream the Reedy river offers a large amount of power, which is well utilized. There are shoals on some of its tributaries, but the powers are small. Laurel creek, which comes in above Ashmore's, has a shoal not used; and Reaburn's creek, a large stream, has one good shoal about nine miles from Laurens, with a fall of 26 feet over a solid rock ledge, used by Goodgion's grist- and saw-mills. Less than a mile above, on the same stream, is the old Fuller factory-site, now used by a saw- and grist-mill, with a fall of 14 feet.

It remains to say a few words about the three forks of the Saluda.

The North fork drains an area of about 56 square miles, and is a mountain stream, like the north fork of the Pacolett, with a rapid fall, but small volume of water. It has at one place a perpendicular fall, over a gneiss ledge, of between 200 and 300 feet, and at another place a similar fall not quite so high. The stream unites with the Middle fork, which drains 66 square miles, and below the junction, about 13 miles from Greenville, there is one grist-mill, with a fall of 9 feet over a rock shoal. A mile below is a shoal not used, with 12 feet fall; and there are doubtless numerous other places where power could be obtained. On the Middle fork itself there is one grist-mill, 16 miles from Greenville, with a fall of 18 feet, which could probably be increased by raising the dam. It is said to be an excellent small power. The dam is 5 feet high, 200 feet long, and the head-race is of the same length. The mill is not in use at present, and the dam is out of repair. This site is situated about a mile above the junction of the two forks.

The South fork has a very rapid fall, and numerous shoals which might be utilized, but with small volume of water and inaccessible locations. All the headwaters abound in cataracts and precipitous falls, many of several hundred feet almost vertical. The drainage area of this fork is 78 square miles or thereabout.

Finally, the large amount of space which it has been necessary to devote to the Santee river and its tributaries shows that the drainage-basin abounds in the finest kind of water-powers. It would be difficult to select another stream of equal drainage area which can offer so large a number of excellent powers, from the smallest to the largest. From the great falls of the Catawba, with a fall of 173 feet, to the numberless fine small powers on the smaller streams in western South Carolina, the range is large, and offers powers of all scales of magnitude; and as the manufacturing interest in the South develops, there is no doubt that many of the fine powers now lying idle will be turned to account. Hand in hand with this development will go the construction of railroads, until the southern streams become, like many of the northern ones, a succession of mill-ponds, with all kinds of manufactures on their banks, and the country becomes threaded with a network of railroads and studded with factory villages.

Table of utilized power on the Santee river and tributaries.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Santee	Atlantic	South Carolina			0	0.0	0
Tributaries below forks	Santee	do			0	0.0	0
Wateree (Catawba)	do	do	Kershaw	Flour and grist	1	7.0	20
Do	do	do	Chester	do	1	18.0	25
Do	do	do	Lancaster	do	1	4.0	20
Do	do	do	York	do	4	30.0	86
Do	do	North Carolina	Mecklenburg	do	3	11.0	55
Do	do	do	Gaston	do	2	19.0	30
Do	do	do	do	Saw	1	9.0	13
Do	do	do	do	Cotton factory	1	22.0	105
Do	do	do	Iredell	Flour and grist	1	15.0	15
Do	do	do	do	Saw	2	32.0	40
Do	do	do	Catawba	Flour and grist	1	6.0	16
Do	do	do	do	Cotton factory	2	12.5	80
Do	do	do	Alexander	Flour and grist	1	3.0	6
Do	do	do	Caldwell	do	1	9.0	20
Do	do	do	do	Saw	2	21.0	30
Do	do	do	do	Carriage and wagon factory	1	9.0	10
Do	do	do	Burke	Saw	3	39.0	56
Do	do	do	McDowell	Flour and grist	2	23.0	32
Tributaries to	Wateree	South Carolina	Sumter	do	[illegible]	45+	74
Do	do	do	do	Saw	2	13.0	25
Do	do	do	Kershaw	Flour and grist	12	89+	170
Do	do	do	do	Saw	3	29.0	70
Do	do	do	Fairfield	Flour and grist	2	33.0	16
Do	Catawba	do	Chester	do	9	116+	172
Do	do	do	do	Saw	1	18.0	7
Do	do	do	do	Cotton factory	2	39.5	......
Do	do	do	Lancaster	Flour and grist	5	46+	85
Do	do	do	York	do	14	189.5	304
Do	do	do	do	Saw	[illegible]	06.0	180
Do	do	do	do	Cotton-gin	1	16.0	12
Do	do	North Carolina	Mecklenburg	Flour and grist	14	194.0	206
Do	do	do	do	Saw	8	114.0	78
South fork Catawba	do	do	Gaston	Cotton factory	5	64.0	425
Do	do	do	do	Flour and grist	5	61.0	64
Do	do	do	do	Saw	2	17.0	20
Do	do	do	Lincoln	Paper	2	21.0	270
Do	do	do	do	Chair factory	1	8.0	30
Do	do	do	do	Flour and grist	2	10.0	60
Do	do	do	do	Cotton factory	1	6.5	50
Do	do	do	Catawba	Flour and grist	3	52.0	37
Do	do	do	do	Saw	3	30.0	34
Tributaries to	South fork Catawba	do	Gaston	Flour and grist	[illegible]	128.0	122
Do	do	do	do	Saw	4	68.0	100
Do	do	do	Lincoln	Flour and grist	8	131.5	113
Do	do	do	do	Saw	3	32.0	35
Do	do	do	do	Cotton-gin	5	48.0	44
Do	do	do	do	Leather works	3	52.0	28
Do	do	do	do	Millwrighting	1	18.0	15
Do	do	do	Catawba	Flour and grist	4	60.0	47
Do	do	do	do	Woolen	1	8.0	8
Do	do	do	do	Iron casting, etc	1	10.0	20
Do	do	do	do	Blomaries and forges	1	......	30
Do	Catawba	do	Gaston	Cotton factory	1	8.0	50
Do	do	do	do	Flour and grist	3	40.0	34
Do	do	do	do	Saw	2	28.0	10
Do	do	do	do	Cotton-gin	1	20.0	10
Do	do	do	Lincoln	Flour and grist	6	71.5	60
Do	do	do	do	Saw	4	36.0	33
Do	do	do	do	Blomaries and forges	1	13.0	40
Do	do	do	do	Woolen	1	......	12
Do	do	do	Catawba	Flour and grist	7	125.0	110
Do	do	do	do	Saw	2	34.0	30
Do	do	do	do	Blomaries and forges	1	12.0	20
Do	do	do	do	Miscellaneous	3	45.0	23

Table of utilized power on the Santee river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries to	Catawba	North Carolina	Alexander	Flour and grist	10	115.0	153
Do	do	do	do	Saw	4	58.0	62
Do	do	do	do	Cotton factory	1	12.0	20
Do	do	do	Caldwell	Flour and grist	13	250.0	157
Do	do	do	do	Saw	7	104.0	155
Do	do	do	do	Woolen	1	6.0	
Do	do	do	Burke	Flour and grist	13	213+	255
Do	do	do	do	Saw	4	60+	55
Do	do	do	do	Woolen	2	16.0	28
Do	do	do	McDowell	Flour and grist	9	133.0	92
Do	do	do	do	Woolen	2	16+	20
Congaree	Santee	South Carolina	Richland	Flour and grist	2	21.0	70
Do	do	do	do	Water-works	1	12.0	40
Tributaries of	Congaree	do	do	Flour and grist	8	77.0	77
Do	do	do	do	Saw	3	32.0	35
Do	do	do	Lexington	Flour and grist	5	41.0	57
Do	do	do	do	Saw	6	52.0	55
Do	do	do	do	Cotton-gin	1	4.0	10
Do	do	do	do	Cotton factory	1	12.0	40
Broad river	do	do	do	Flour and grist	3	23.0	70
Do	do	do	do	Saw	1	10.0	10
Do	do	do	Fairfield	Flour and grist	1	15.0	30
Do	do	do	Chester	do	1	8.0	15
Do	do	do	Union	do	2	25.0	40
Do	do	North Carolina	Cleaveland	do	2	16.0	22
Do	do	do	Rutherford	do	2	38.0	24
Do	do	do	do	Saw	1	20.0	15
Enoree river	Broad	South Carolina	Newberry	Flour and grist	1	4.5	15
Do	do	do	Union	do	1	3.0	8
Do	do	do	Spartanburgh	do	3	40.0	42
Do	do	do	Laurens	do	6	78.0	123
Do	do	do	do	Saw	2	25.0	30
Do	do	do	Greenville	Cotton-gin	2	21.0	11
Do	do	do	do	Saw	1	20.0	20
Do	do	do	do	Flour and grist	5	79.0	67
Do	do	do	do	Cotton factory	1	18.0	60
Do	do	do	do	Woolen	1	15.0	8
Tributaries of	Enoree	do	Newberry	Flour and grist	1	9.0	16
Do	do	do	Laurens	do	4	63.0	56
Do	do	do	Greenville	do	7	122, 0	70
Do	do	do	do	Cotton-gin	7	106.0	50
Do	do	do	do	Cotton factory	1	48.0	48
Tiger river	Broad	do	Spartanburgh	Flour and grist	5	80.0	73
Do	do	do	do	Saw	1	9.0	18
Do	do	do	do	Cotton-gin	4	69.0	32
Tributaries of	Tiger	do	do	do	4	70.0	38
Do	do	do	do	Flour and grist	16	294.0	198
Do	do	do	do	Saw	7	105.0	74
Do	do	do	do	Cotton factory	1	17.0	35
Do	do	do	Union	Flour and grist	3	58.0	24
Do	do	do	do	Saw	1	6.0	8
Do	do	do	Greenville	Flour and grist	1	25.0	18
Do	do	do	do	do	6	95.0	80
Pacolett river	Broad	do	Union	Flour and grist	3	16.0	28
Do	do	do	do	Saw	1	4.0	10
Do	do	do	Spartanburgh	Flour and grist	1	10.0	15
Do	do	do	do	Saw	2	18, 0	44
Do	do	do	do	Cotton factory*	1		
Do	do	do	do	Woolen	1	11.0	4
Tributaries of	Pacolett	do	do	Flour and grist	9	136.0	165
Do	do	do	do	Saw	10	133.0	145
Do	do	do	do	Cotton-gin	5	75.0	60
Do	do	do	do	Leather	1	18.0	10
Do	do	do	do	Cotton factory	3		280
Do	do	do	do	Woolen	2	20+	20
Do	do	do	Greenville	Flour and grist	2	33.0	28

*Being built.

Table of utilized power on the Santee river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Broad	South Carolina	Lexington	Flour and grist	2	12+	25
Do	do	do	Newberry	do	1	18.0	11
Do	do	do	Union	do	5	60.0	79
Do	do	do	Fairfield	do	2	19.0	16
Do	do	do	do	Saw	1	11.0	25
Do	do	do	Chester	Flour and grist	3	79.0	75
Do	do	do	York	do	14	207.0	204
Do	do	do	do	Saw	3	......	49
Tributaries of	do	North Carolina	Cleaveland	Flour and grist	16	240.0	220
Do	do	do	do	Saw	10	179.0	147
Do	do	do	do	Cotton-gin	1	......	......
Do	do	do	do	Paper	1	16.0	75
Do	do	do	do	Cotton factory	2	23.0	70
Do	do	do	Polk	Flour and grist	1	23.0	35
Do	do	do	do	Saw	1	22.0	34
Do	do	do	Rutherford	Flour and grist	18	254.0	277
Do	do	do	do	Saw	4	......	45
Do	do	do	do	Woolen	1	12.0	[illegible]
Do	do	do	do	Leather	1	50.0	40
Do	do	do	do	Cotton-gin	1	12.0	20
Do	do	do	McDowell	Flour and grist	4	51.0	51
Saluda	Congaree	South Carolina	Lexington	do	5	21.0	62
Do	do	do	do	Cotton factory	1	16.0	150
Do	do	do	Greenville	Flour and grist	4	48.0	62
Do	do	do	do	Cotton factory	1	20.0	800 ?
Do	do	do	Edgefield	Flour and grist	3	7+	34
Do	do	do	Abbeville	do	5	42.0	160
Do	do	do	do	Saw	1	......	10
Do	do	do	Anderson	Flour and grist	2	......	42
Do	do	do	do	Saw	1	9.0	8
Do	do	do	Pickens	Flour and grist	1	8.0	18
Do	do	do	do	Cotton-gin	1	6.0	10
Reedy river	Saluda	do	Laurens	Flour and grist	7	79.0	136
Do	do	do	do	Saw	2	18.0	35
Do	do	do	Greenville	Cotton factory	3	86.0	510
Do	do	do	do	Wagon factory	1	6.5	8
Do	do	do	do	Box factory	1	32.0	20
Do	do	do	do	Blacksmithing	1	6.0	6
Do	do	do	do	Paper	1	11.5	......
Reedy and tributaries	do	do	do	Flour and grist	20	359.0	249
Do	do	do	do	Cotton factory	1	20.0	40
Do	do	do	do	Woolen	1	26.0	......
Do	do	do	do	Saw	4	61.0	58
Do	do	do	do	Cotton-gin	3	56.0	75
Do	do	do	do	Leather	1	14.0	6
Do	do	do	do	Saw	8	214.0	111
Do	do	do	do	Cotton-gin	5	60.0	31
Tributaries of	Reedy	do	Laurens	Flour and grist	3	57.0	18
Do	do	do	do	Saw	2	34.0	19
Do	do	do	do	Woolen	1	26.0	8
Do	Saluda	do	Lexington	Flour and grist	6	39.0	51
Do	do	do	do	Saw	4	30.0	70
Do	do	do	do	Brick and tile	1	8.0	8
Do	do	do	Newberry	Flour and grist	[illegible]	81.0	77
Do	do	do	do	Saw	1	8.0	15
Do	do	do	do	Cotton-gin	4	25.0	24
Do	do	do	Laurens	Flour and grist	3	39.0	45
Do	do	do	Greenville	do	6	......	60
Do	do	do	Edgefield	do	5	25+	80
Do	do	do	Abbeville	do	2	44.0	20
Do	do	do	Anderson	do	4	55.0	58
Do	do	do	do	Saw	2	27.0	18
Do	do	do	Pickens	Flour and grist	11	200.0	02
Do	do	do	do	Saw	5	75.0	71
Do	do	do	do	Cotton-gin	10	190.0	100
Do	do	do	do	Woolen	2	26.0	26

VIII.—THE EDISTO RIVER AND TRIBUTARIES.

THE EDISTO RIVER.

The streams flowing into the Atlantic between the Santee and the Savannah are, in general, valueless as sources of water-power, only one of them, the Edisto river, being worthy of mention. They rise for the most part below the fall-line, flow through a low and swampy country, and are entirely without power, except on some of their small upper branches, which belong to the class of sand-hill streams. The Edisto river, however, rises farther inland than the others (both of its forks having their sources in Edgefield county, above the fall-line), and some of its branches are worthy of mention. Although these streams cross the fall-line, there are no falls of importance on them so far as I could learn, or, if there are, they occur where the streams are very small. The greater part of the course of the Edisto lies in a swampy country, and has no water-power; but on the north fork and its tributaries, and especially on the south fork and one of its branches (Shaw's creek), there is considerable available power. Shaw's creek belongs to the class of sand-hill streams, and drains an area of about 119 square miles, uniting with Rocky creek, which drains an area of 195 square miles, to form the south fork of the Edisto. My information regarding these streams is necessarily very meager. They are utilized to some extent by saw- and grist-mills, and could doubtless be made to afford considerable power, their flow being probably from one-half to one cubic foot per second per square mile, with facilities, generally, for storing the water during the night. Shaw's creek has been used in half a dozen places, and it has been considered a better and larger stream than Horse creek, described further on. It is said to be even more constant than Horse creek, but its fall is probably less.

These streams are no doubt worthy of attention as regards power, although I can give no information regarding particular sites.

Table of power utilized on the Edisto river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Fall used.	Horse-power used.
						Feet.	
Tributary to	Edisto	South Carolina	Barnwell	Saw	2	20.0	28
Do	do	do	do	Flour and grist	2	18.0	16
Do	do	do	do	Cotton-gin	4	30.0	21
Do	do	do	Orangeburgh	Flour and grist	8	81.5	86
Do	do	do	do	Saw	9	97.0	112
Do	do	do	do	Cotton-gin	8	61+	42
Do	do	do	Aiken	Flour and grist	16	145.0	209
Do	do	do	do	Stone and earthen ware	1	8.0	40
Do	do	do	do	Saw	17	152+	325
Do	do	do	do	Cotton-gin	4	14+	21
Do	do	do	Edgefield	Flour and grist	2	20.0	31
Do	do	do	Lexington	do	4	46.0	56
Do	do	do	do	Saw	9	81.5	139

IX.—THE SAVANNAH RIVER AND TRIBUTARIES.

THE SAVANNAH RIVER.

The Savannah river, which constitutes for its entire length the boundary-line between the states of South Carolina and Georgia, is formed by the union of the Tugaloo and the Seneca rivers, both of which streams rise in the Blue Ridge, in the southern part of North Carolina, uniting on the line between Anderson county, South Carolina, and Hart county, Georgia. The Savannah pursues a nearly straight course to the ocean in a southeasterly direction, its length being about 180 miles in a straight line, and about 355 miles by the course of the river. The upper part of the stream is more nearly straight than the lower, the distance between Augusta and the head of the river being about 85 miles in a straight line and 107½ by the river. The stream crosses the fall-line at Augusta, which is the only important town on the river, and the head of steamboat navigation.

As will be seen from the map, the drainage-basin of the river is long and narrow. Its total area is between ten and eleven thousand square miles, the maps differing to such a degree that it is impossible to determine it accurately. That part above the fall-line, or the head of the Augusta canal, measures about 6,850 square miles. Below that point the only water-power in the basin is on some tributary creeks, some of which are true sand-hill streams. Above Augusta there is considerable power on the river itself and on its principal tributaries, viz: Broad, Little, and Rocky rivers (the last two from South Carolina), which drain respectively 1,500, 530, and 240 square miles, as well as on the Tugaloo and Seneca, which drain respectively 870 and 908 square miles. Of the 107½ miles between Augusta and the head of the river 28½ miles are occupied by shoals. The general character of the drainage-basin is the same as that of the Santee, Congaree, and Broad rivers. The rainfall is about 50 inches, distributed as follows: spring, 13; summer, 13; autumn, 10; winter, 14. It varies from 44 inches and less below Augusta to 56 inches and over in the mountains. The table on page 131 gives better data regarding the variation in different parts of the basin. The stream is subject to heavy freshets, due to the melting of snows in the mountains and to heavy falls of rain. The average rise in freshets is about 16 feet, but sometimes this is greatly exceeded. In August, 1852, the stream rose 44 feet in 48 hours at Petersburg (about 59 miles above Augusta), and in 1875 it rose at the same place 38 feet in 36 hours. At Augusta it has been known to rise about 40 feet, inundating the streets to a depth of 4 feet or more. Freshets occur most frequently during May and August. They subside much less rapidly than they rise. Below Augusta the rise is smaller as the ocean is approached, being 18 feet at a point 133 miles lower down, and 5 feet at a point 15 miles above Savannah.

The bed of the stream above the fall-line, like that of the other streams we have described, is rock, sometimes overlaid with clay, gravel, and sand. The fall of the stream is shown by the following table:

Table of declivity of the Savannah river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile.*
Mouth	0.0	0.0			
			170.0	68.6	0.40
Steel creek	170.0	68.6			
			33.0	10.3	0.31
Haynes' cut	203.0	78.9			
			27.0	29.1	1.08
Silver bluff	230.0	108.0			
			18.0	22.4	1.24
Augusta	248.0	130.4			
			107.5	270.0	2.51
Andersonville	355.5	400.0			

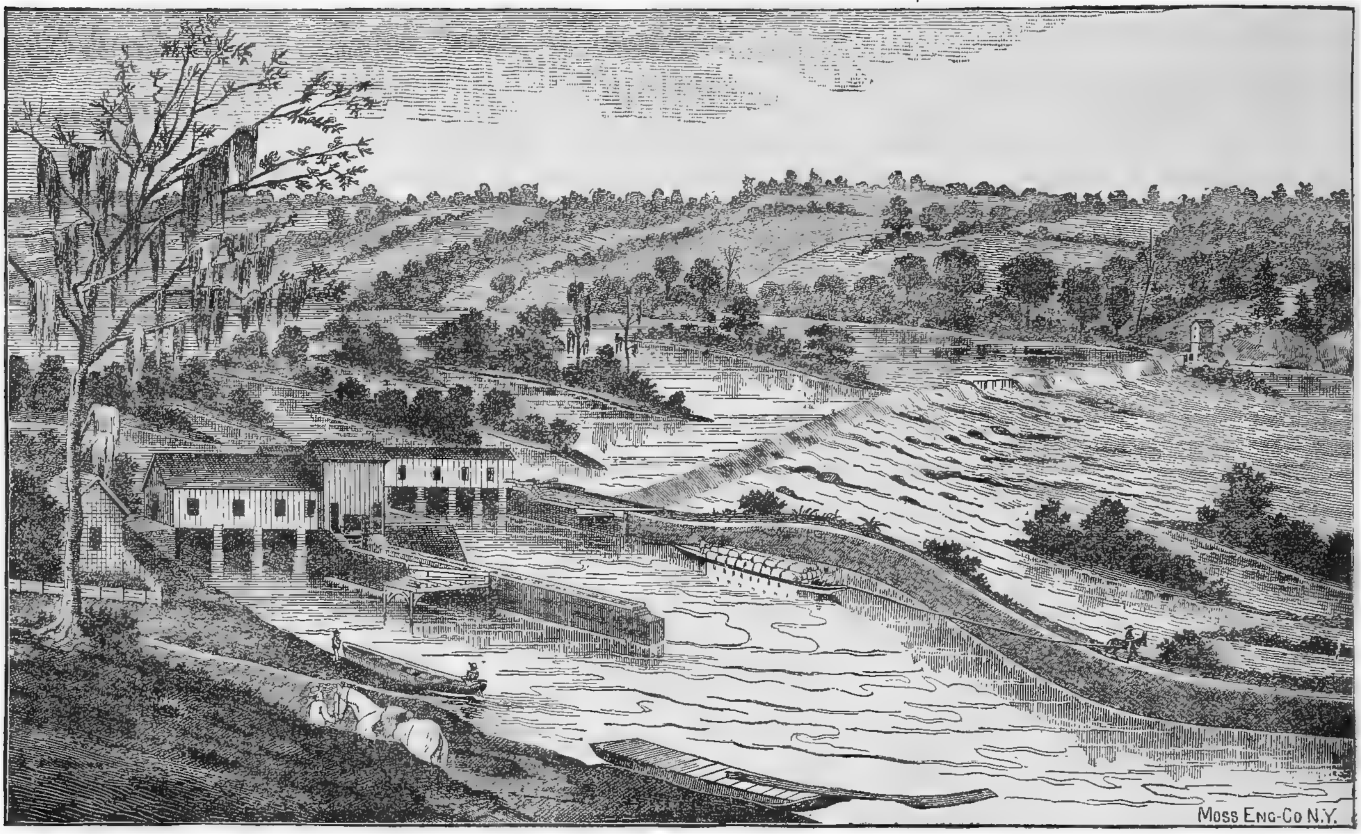
No gaugings of the stream of any value could be obtained.

The principal productions of the drainage-basin are corn and cotton, with some tobacco. The country is well timbered, and there are several gold and iron mines near the river. The map will show that the stream is not very accessible, the nearest railroad points above Augusta being Washington, Elberton, Hartwell, and Anderson, their distances from the river varying from 6 to 25 miles. The Savannah Valley railroad, now being constructed, will run from Augusta up the river for 15 miles on the Georgia side, then, crossing and running within 8 miles of the stream for 25 miles in South Carolina, to Greenwood, on the Greenville and Columbia railroad.

The Savannah river has been examined by United States engineers under the direction of General Q. A. Gillmore, whose report is to be found in the *Annual Report of the Chief of Engineers* for 1879, page 747, and from which most of the following information regarding the shoals on the river has been obtained. A reconnoisance of the river above Augusta was also made in 1874 by W. W. Thomas, civil engineer, for the city of Augusta.

Water-powers.—The first power met with in ascending the stream is at Augusta, Georgia, at which city we find one of the largest and most important utilized powers in the South, supplied from a canal 7 miles long, at the head of which is a dam entirely across the river. Before giving its technical features, a few points regarding the history of the development of this power will be interesting. The canal was commenced in 1845 and completed in 1847, under the direction of the board of commissioners appointed by the city "for the purpose of constructing a canal from a point on the Savannah river about seven miles above to the city of Augusta for manufacturing purposes, and for the better securing of an abundant supply of water to the city". Its original dimensions were as follows: width at surface, 40 feet; at bottom, 20 feet; depth, 5 feet. It was soon found, however, that these dimensions were too small to supply the demand for power and for water-supply, and the banks were raised, increasing the depth to 7 feet, but still without increasing the capacity to a sufficient extent. In 1872 it was decided to enlarge the dimensions very materially, and the work was commenced in March of that year, and completed about the middle of the year 1875. An embankment was constructed on the river side, but on the land side the water was not confined, except in places where cutting was necessary, but was allowed to flow back, cutting a contour line from the surface of the ground, and forming a number of ponds at points where valleys run down to the river,

having a total area of 275 acres, exclusive of what may be considered the canal proper. The total area of ponds and canal is about 400 acres. The dimensions of the latter are: length, 7 miles; surface width, 150 feet; bottom width, 106 feet; depth, 11 feet; area of cross-section, 1,408 square feet. The bottom is graded to a fall of about half a foot per mile, giving, if the surface of the water has the same inclination, a velocity of about 2.7 feet per second, or a discharge of about 3,800 cubic feet per second. The dam at the head of the canal, which is located in a very favorable place, is shown in the accompanying illustration. It is 1,720 feet long, 10.63 feet high on the average,



DAM AND BULKHEAD OF AUGUSTA WATER-POWER.

varying from 6 to 15 feet, and is built of solid stone, in cement, on a foundation of solid rock. It extends diagonally up stream for 1,000 feet from the bulkhead, and then 720 feet straight across, and is provided with four waste-weirs, three of them 20 feet wide and the other 15 feet, which may be closed by needles. In section it is a trapezium, its face sloping at an angle of 45°, its back one-half horizontal to one vertical, and its top at an angle of 15° backward and downward. The horizontal width of its top is 6½ feet. At one end are the locks and bulkhead, all built in the most substantial manner of granite, laid in hydraulic cement, the stone having been all obtained within a mile of the place. The cost of the dam, which was completed in 1876, was about $87,000, and that of the remaining works at the head of the canal was $132,000, making a total of $219,000. The pond extends for about 1½ or 2 miles, with an average width of 1,500 feet, interspersed with islands and rocks. The dam has never been injured by freshets or ice, and is built in such a solid way that there is no danger of its ever being disturbed—the water having stood, in one instance, 9 feet above its crest.

The fall at Augusta between the level of the canal and low water in the river is in the neighborhood of 50 feet, but the fluctuations in the river render it impossible to utilize this fall economically. Below the main canal are two other levels, aggregating about 2 miles in length, the second and third levels being, respectively, 18 and 33 feet below the first or main canal. Power is used from all three levels, the table on the following page showing in what way and to what extent. The mills can generally be run at full capacity all the time, those on the second level being troubled sometimes, but not often, with backwater from the river. The Summerville mills have worked under 16 feet of backwater.

The power at Augusta is owned entirely by the city, water being leased to the different mills at the rate of $5.50 per horse-power. The method of determining the amount of power used is optional with the city engineer, who can actually gauge the water consumed when the machinery is in full operation, or, if he chooses, judge from the size of wheel, without measurement. All the works connected with the canal were built by the city, under Mayor Charles Estes, the moving spirit of the enterprise, the total cost, including 400 acres of land, amounting

to $822,000. This land includes fine building-sites, as well as space for operatives' houses, the available fall between the canal and the river varying between 33 and 40 feet. The accompanying map will show the location of these lands.

The drainage area of the Savannah river above the head of the Augusta canal is about 6,830 square miles, and the rainfall about 50 or 52 inches, distributed as follows: spring, 14; summer, 13; autumn, 10; winter, 15. I have therefore estimated the power as follows:

Table of power at Augusta, Georgia.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.			
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	33 *feet fall.*	40 *feet fall.*	50 *feet fall.*
Minimum	6, 830	*33 to 40+	1, 700	193. 2	6, 375	7, 728	9, 660
Minimum low season			2, 100	238. 7	7, 877	9, 548	11, 935
Maximum, with storage			6, 000	681. 8	22, 500	27, 272	34, 090
Low season, dry years			2, 400	272. 7	9, 000	10, 908	13, 635

* See description.

The existing canal is of sufficient capacity to carry the entire flow of the stream in dry seasons. The storage room offered by the canal and ponds would be sufficient to allow of the power used during 12 hours being increased to some extent above that afforded by the stream in the low season of dry years, but not to any great extent. The utilization of the maximum power could only be effected at great cost.

The power just described is one of the finest in the South. The advantages of transportation are of the best, building-stone of the best quality can be had with ease, the locality is healthy, and large amounts of power can be rented from the city on favorable terms. These advantages are being rapidly improved. The Sibley mills, now being built, will use 1,000 horse-power, and the company expect to double their capacity within a short time, and eventually to triple it. As the advantages become more widely known the surplus power here available must be rapidly utilized.

Table of power utilized at Augusta, Georgia.

I.—WATER TAKEN FROM MAIN CANAL (FIRST LEVEL) AND DISCHARGED TO RIVER.

[The powers given are those to which the different mills are entitled. The figures differ from those in the statistics of the special agent on cotton-mills.]

Name and kind of mill.	Fall.	Horse-power.	Remarks.
	Feet.		
1. Summerville cotton-mills	32. 00	170. 00	Hercules wheel. Fall of 11 feet to tail-race at low water. Highest mill on the canal, 2 miles above the basin, or lower end of main canal.
2. Sibley Manufacturing Company, cotton	38. 00	1, 000. 00	Now building. 100 looms and 3,000 spindles. Expect to double capacity soon.

II.—WATER TAKEN FROM FIRST LEVEL AND DISCHARGED TO SECOND.

1. Enterprise Manufacturing Company, cotton	16. 44	395. 00	
2. Augusta flour-mills	13. 00	200. 00	John M. Clark's Sons. Have lately increased power above that given.
3. Augusta cotton factory	15. 25	1, 200. 00	850 horse-power actually used.

III.—WATER TAKEN FROM SECOND LEVEL AND DISCHARGED TO THIRD, OR TO RIVER.

1. Schley's grist-mill	12. 07	54. 50	
2. Globe cotton factory	12. 30	91. 00	John M. Clark's Sons.
3. Augusta Paint Company	12. 30	25. 00	
4. Southern Cross cotton factory	12. 20	61. 88	
5. Cottonseed-oil mill	11. 50	56. 00	
6. Excelsior flour-mill	11. 00	152. 00	George T. Jackson & Co.
7. Foundry and planing-mill	11. 00	13. 00	Pendleton & Bro.
8. City water-works pump	11. 00	45. 00	
9. Arctic Ice Company	11. 00	62. 26	
10. Crescent flour-mill	10. 63	125. 00	L. F. & L. J. Miller.

The next power above Augusta is at Blue Jacket shoal, where the fall is 10 feet in 200 yards. Then comes Long shoal, with a fall of 35 feet in 5 miles. The average width of the river is 600 yards. The head of the shoal is

about 5 miles below the mouth of Little river, South Carolina. Then follow a number of smaller shoals, many of which may offer good sites for power, to determine which a survey would be necessary. The most important shoal, however, is Trotter's shoal, which is 7 miles long, with a total fall of 74.88 feet. The head of the shoal is at the mouth of Rocky river, South Carolina, and the foot 5 miles above the mouth of Broad river, Georgia. This shoal probably offers the finest power on the river above Augusta, and is now almost entirely unutilized, being only used for a couple of small grist-mills. The river descends over a series of ledges of solid rock, and is, on the average, 800 yards wide. The banks are said to offer no difficulties as regards the construction of canals or buildings. The river rarely rises so much as 10 feet during freshets, and there is of course no trouble with ice. Fine building-materials—granite, timber, clay for brick, and soapstone—abound in the neighborhood, and iron and gold are said to have been found close by the river. The surrounding country is well adapted for the cultivation of corn and cotton, the climate is healthy, and although the site is at present rather inaccessible, being about 15 miles distant from Elberton and Abbeville, the nearest railroad points, yet the proposed Savannah Valley railroad will pass close by the shoals on the South Carolina side, while the Hartwell and Augusta railroad, now talked of, will, if built, pass close to them on the Georgia side.* As regards water communication, it may be mentioned that steamboat navigation can probably be opened up to the foot of the shoals, the estimated cost of securing a channel 3 feet deep and 90 feet wide being $124,000,† while the cost of improvement for a pole-boat channel 3 by 30 feet was estimated at $45,000. The sum of $16,000 has been appropriated to the work.

I am indebted for much valuable and detailed information concerning these shoals to Colonel James Edward Calhoun. The power available has been estimated as in the following table:

Estimate of power at Trotter's shoals.

State of flow.	Drainage area.	Fall.	Rainfall.					Flow per second.	Horse-power available, gross.	
			Spring.	Summer.	Autumn.	Winter.	Year.			
	Sq. miles.	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Cubic feet.*	*1 foot fall.*	*75 feet fall.*
Minimum	2,664	74.88	15	14	10	16	55	670	76.1	5,700
Minimum low season								950	108.0	8,100
Maximum, with storage								2,550	290.0	21,750
Low season, dry years								1,075	122.2	9,165

Although all of the other falls on the Savannah were ascertained by measurement with an aneroid barometer, the fall of Trotter's shoal was measured more accurately with a leveling-instrument. I did not visit this shoal, and all my information is therefore derived from reports and correspondence. It is proper to say, however, that every one whom I questioned regarding it said it afforded one of the finest powers they had ever seen. It is therefore certainly worthy of attention.

The remaining shoals on the river, with estimates of the power available, will be found in the table. Regarding them I have meager information. Cherokee shoal is 5 miles below the mouth of Van's creek, Georgia; Gregg's shoal is just above the mouth of Pickens' creek, Georgia, and just at the line between Anderson and Abbeville counties, South Carolina; Middleton's shoal is just below the mouth of Little Generostee creek, South Carolina; and McDaniell's shoal is 2 miles above Cedar creek, Georgia. Some of these shoals, and some of the smaller falls between them, have been used at different times for small grist- and saw-mills, but there is no other manufacturing of any kind on the river above Augusta except at one small woolen-mill. To determine the availability of these shoals personal examination would be necessary. It is improbable that much power will be used on the river for some time, for the great width of the stream renders dams expensive, and except at places where considerable fall can be secured, as at Trotter's shoal, it would perhaps hardly pay to utilize power very extensively, although small mills with wing-dams could be located at many places. In Anderson county the banks of the river are said to be quite bluffy, so that canaling would be difficult and costly; but below that county the country is said to be more open, and canals to be practicable. It was stated by persons acquainted with the river that Gregg's and Middleton's shoals would be hard to utilize on account of the high banks, although both have been used to a small extent for saw-mills; but that Cherokee shoal, on the contrary, could be easily used, and the whole fall rendered available. There is now a mill at these shoals with a wing-dam 5 feet high, a canal a mile long, and a fall at the mill of 16 feet.

The table on the following page gives the power utilized on the river. The only dam across the stream is the one at Augusta.

* Information from Colonel James Edward Calhoun.

† *Annual Report of Chief of Engineers*, 1879, p. 749.

Summary of power on the Savannah river.

Place.	Distance from Augusta.	Drainage area.	Rainfall.					Fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	Sq. miles.	In.	In.	In.	In.	In.	Feet.							Feet.		
Augusta	0.00	6,830	14	13	10	15	52	33–40	7 miles	6,375	7,877	22,500	9,000	3,650	38	......	See description.
Blue Jacket shoal	19.00	5,800±	14	13	10	15	52	10	600 feet	1,650	2,050	5,800	2,350	......	......	......	Only power utilized is for small grist- or saw-mills.
Long shoal	30±	5,135	14	13	10	15	52	35	5 miles	5,100	6,350	18,000	7,250	......	......	......	
Trotter's shoal	64.00	2,664	15	14	10	16	55	75	7 miles	5,700	8,100	21,750	9,165	......	......	......	
Cherokee shoal	75.50	2,212	15	14	10	16	55	9	0.5 mile	560	800	2,100	900	......	......	......	
Bowman's ledge	83.00	......	15	14	10	16	55	3	120 feet	......	......	......	......	......	......	......	
Gregg's shoal	85.50	2,100	15	14	10	16	55	14	1 mile	825	1,150	3,200	1,325	......	......	......	
Middleton's shoal	88.50	2,078	15	14	10	16	55	18	1 mile	1,060	1,500	4,000	1,700	......	......	......	
Ferrill's ledge	89.75	......	15	14	10	16	55	3	360 feet	......	......	......	......	......	......	......	
McDaniell's shoal	95.50	1,900	15	14	10	16	55	30	5 miles	1,600	2,275	6,100	2,600	......	......	......	
TUGALOO RIVER (see beyond).																	
Hatton's shoal	110.00	845	15	15	10	16	56	39	1½ mile	936	1,131	4,095	1,287	0	0	0	No power utilized on the river.
Guest's shoal	113.50	775	15	15	10	16	56	17	1 mile	375	450	1,650	520	0	0	0	
SENECA RIVER (see beyond).																	
Portman's shoal	113.00	740	15	15	10	16	56	60	2 miles	1,290	1,700	5,620	1,950	0	0	0	No power utilized on the river.

* See pages 18 to 21.

TRIBUTARIES OF THE SAVANNAH RIVER.

The first considerable tributary of the Savannah river is Briar creek, which rises in Warren county, Georgia, and pursues a southeasterly course through a distance of about 85 miles in a straight line, draining an area of 830 square miles, and entering the Savannah river in Screven county. It crosses the fall-line near its source, but with no great fall at that point, and its water-power is of little consequence. Some of its tributaries may be classed as sand-hill streams, and afford small powers.

Lower Three runs and Upper Three runs, from Barnwell and Aiken counties, South Carolina, are two sand-hill streams, which could be made to afford considerable power, although at present only a small amount is utilized. Lower Three runs drains an area of 140 square miles, and is some 25 miles long, while Upper Three runs drains 165 square miles, and is over 30 miles long. Both have gradual declivities, beds of sand and clay, and considerable swamp-land along their courses. Lower Three runs has a few corn- and saw-mills in operation, and several old mill-sites not in use. It has a gradual fall of 12 or 15 feet per mile in its upper parts, according to Mr. James E. Crossland, civil engineer and surveyor, of Aiken, South Carolina, and it offers good facilities for storage. If we take its flow at from one-half to one cubic foot per second per square mile (see page 85), it will be found that the stream will afford at its mouth 8 to 16 horse-power per foot. Gaugings only can determine whether this estimate is correct. At the mouth of the stream, however, there are no sites for power. Upper Three runs, the larger stream of the two, is also a better stream. It has not so much swamp-land, has better banks, and has a greater fall, amounting to from 18 to 20 feet per mile in places, according to Mr. Crossland.* It is crossed at its mouth, near Ellenton, by the Port Royal and Augusta railroad, and near its headwaters by the South Carolina railroad. Its width varies from 120 feet at its mouth, and 100 feet a few miles above, to 75 feet at a distance of 15 miles above. The first power is at Newman's, just above the railroad bridge, where there was formerly a mill having a fall of 7 feet. The dam is still there, and is of dirt, and the site is said to be a very good one. A few miles above is a second good power, at Rouse's bridge, not now used. According to Mr. Crossland, there are now in operation on the stream and tributaries twelve grist- and saw-mills, and one cotton-yarn mill running the Clement-attachment, and also six sites formerly used, but now idle. According to the supposition above made regarding the flow of the stream, it would afford at its mouth from 9 to 18 horse-power per foot fall.

The tributaries to the Savannah from Richmond county, Georgia, afford some power, and some of them are sand-hill streams, but none are of much importance. There are also in this county some sand-hill tributaries to Briar's creek which afford good small powers, with large ponds, allowing of concentration of power during working

* I am indebted to Mr. Crossland for considerable information regarding these streams and for a map of Upper Three runs.

hours, the principal one of these streams being Sandy run. Of the streams flowing directly into the Savannah the principal are McBean's creek and Spirit creek, the former draining 92 square miles. They are used by grist- and saw-mills, with ponds so large that there is no waste except by leakage; and there have been a few cotton factories in the vicinity. There are sites on almost all of these streams, but the powers are too small to be specified in detail.

As regards power utilized, one of the most important tributaries to the Savannah river is Horse creek, a small stream about 20 miles in length, measured in a straight line, and draining about 143 square miles. It enters the Savannah from Aiken county, South Carolina, a few miles below Augusta, and is one of the most important manufacturing streams of South Carolina. It is a true sand-hill stream, and in addition it crosses the fall-line, and has a rapid fall, offering excellent advantages for power. The bed is rock in places, and in others clay and grit, and sometimes sand. The banks are good, and also the facilities for storage, as will be seen from what follows. The stream was early utilized for power, and at present all the good sites are occupied (although one is lying idle), so that it only remains to describe the powers in use: In ascending the stream the first power is at the Bath paper-mills, now not in use, situated 6 miles from the mouth, a mile above the head of boat navigation, and above the mouth of Little Horse creek, the principal tributary of Horse creek, and which drains about 36 square miles. The dam is of earth, 900 feet long and 20 feet high; the pond covers 150 acres to an average depth of 10 or 12 feet; and the head and fall was 38 feet. The dam was built in 1854, and was washed out in 1871 by the breaking of the next dam above (Langley), the damage done amounting to $33,000, the rebuilding of the dam having cost that sum. It was again washed out in 1877, and has not yet been rebuilt. The damages to dam and mill are estimated at $50,000. The power used is stated at 500 to 600 horse-power, there being scarcely ever waste of water. The drainage area above being about 100 square miles, I would estimate the available power due to the natural flow of the stream at from 6 to 12 horse-power per foot fall. It is possible, however, that this site is below the mouth of Little Horse creek, in which case the power would be about one-third greater.

Two miles above Bath is the Langley cotton-mill. The dam is of earth and crib-work, 1,000 feet long and 24 feet high, built in 1870 at a cost of $15,000, and ponding the water over 700 acres to an average depth of 10 feet. The head-race is 300 feet long, the fall 21 feet, and the power used is stated at 500 horse-power, which can be obtained at all times, no steam-power being used, and there being no waste at night in dry weather. I would estimate the power at about the same as for Bath, which would give from 275 to 550 horse-power gross during 11 hours.*

Three miles above Langley, at the town of Graniteville, is the factory of the Graniteville Manufacturing Company, the most important mill on the stream. The dam, which is a continuation of the canal bank, is principally of earth, and extends across Horse creek and one of its tributaries (Bridge creek) just above their junction, the two ponds being connected by a canal about 500 feet long. The dam across Bridge creek is of earth, about 500 feet long and 10 to 20 feet high, and is 10 feet wide on top and 30 or 40 feet at the bottom. It carries the railroad across the creek. The dam across Horse creek is 700 to 800 feet long, and is of earth, with the exception of a rock dam in the center, about 60 by 20 feet, founded on solid rock. There is also a waste-weir about 100 feet long, and the height of both waste-weir and dam can be raised by flash-boards. These dams were built in 1848 and 1867, the rock dam costing $15,000, and the earth dam $35,000. The total pond area is about 100 acres—75 on Horse creek, and 25 on Bridge creek. The canal is half a mile long, 45 to 60 feet wide, and 10 feet deep. The fall used is 43 feet, and the power 600 horse-power, which can be obtained for 300 days in the year by drawing down the water in the pond at night (at all seasons generally), the factory being run during 12 hours. No steam-power is used. The mill is sometimes obliged to stop in dry weather, generally for from 5 to 8 days per year, but in 1879 it was stopped for 17½ days. The dam has been twice carried away, but only once in the last twenty-two years, in 1867, when a heavy rain caused the breaking of 2 dams above. The drainage area above Graniteville being about 81 square miles, if we assume the net power available in dry seasons at 300 horse-power, or the gross power at 400 horse-power, with storage, or 200 horse-power with the natural flow of the stream, we shall find the discharge to be one-half cubic foot per second per square mile. The ordinary power being 600 horse-power net, with storage during the night, or 400 gross due to the natural flow, the corresponding flow is one cubic foot per second per square mile. The flow may be taken to vary between these limits.

Two railroads—the Charlotte, Columbia, and Augusta railroad, and the South Carolina railroad—pass through the town of Graniteville.

The next power above Graniteville is the Vancluse factory of the Graniteville Manufacturing Company, 3 miles above. As in the case of Graniteville, there are two ponds, one formed by a dam across Horse creek, and covering 100 acres, and the other formed by the railroad embankment across Good Spring, and covering 42 acres, the two being connected by a conduit 4½ feet square and 450 feet long, 16 feet below the level of the ponds, and built at a cost of $2,500. The dam across Horse creek is of rock, 300 feet long and 28 feet high, the length of overfall being 60 feet, and was built in 1877 at a cost of $30,000. An iron tube 6½ feet in diameter and 350 feet long, which cost $7,000, conveys the water to the wheels, where the fall is 51 feet. The power used is 300 horse-power, which

* Power stated at 300 horse-power in statistics of special agent on cotton-mills.

can be obtained at all times by drawing down the water in the pond at night. The drainage area being about 56 square miles, the flow is calculated at about 0.6 cubic foot per second per square mile. It probably varies between one-half and one cubic foot.

Above Vancluse there are only a few small grist- and saw-mills on the stream, and none of importance.

Horse creek offers a good example of the large amount of power which can be obtained at small expense from a comparatively insignificant stream if it is only properly developed, and it is the best example of a sand-hill stream in South Carolina. Crossing the fall-line, however, near Graniteville, it offers better facilities for dams, and has more fall than most sand-hill streams, and is therefore peculiarly favorable for power. The rock bed which is found at Graniteville extends only a short distance below, but is found above for some distance. Below the Graniteville dam the bed of the stream is only about 15 feet wide, and it seems wonderful that such a seemingly small stream can afford so much power. As before mentioned, there are no other sites worth mentioning on the stream, and there are said to be few sites for reservoirs.

Some of the small tributaries of Horse creek afford good small powers. Little Horse creek has one site about 3 miles from Graniteville, where there used to be a saw-mill; but the power is not large, and I have no data regarding it.

The next tributary to the Savannah worth mentioning is Big Stevens creek, from Edgefield county, South Carolina, but I was unable to obtain information regarding its power. It is formed by the confluence of several smaller streams which have their sources in Abbeville and Edgefield counties, and the total area which it drains comprises about 650 square miles. From all I could learn, its water-power is not of much importance, and it is stated on good authority that on a great part of its drainage-basin the prevailing rock is a clay-slate, which sheds the water very rapidly, so that the flow of the stream is very variable, like that of some streams in North Carolina to which we have referred. Nevertheless, at its mouth the flow ought to be at least 75 cubic feet per second in very dry seasons, and perhaps 90 to 100 cubic feet in ordinary years in the low season. There are some mills on the stream and its tributaries, but they are of no importance.

The next tributary is Little river, from Georgia, which rises in Greene and Oglethorpe counties, flows in a general easterly direction, forming the boundary-line between Wilkes and Lincoln counties on its left, and Taliaferro, Warren, McDuffie, and Columbia counties on its right, joining the Savannah about 24½ miles above Augusta. Its length, in a straight line, is about 55 miles, and its drainage area about 695 square miles. It is 150 feet wide at its mouth. Its water-power, however, is not of much value. Flowing, as it does, at a small angle with the strike of the rock strata, its fall is not very great, and there are no precipitous descents. Its bed is sand, clay, and gravel, to a greater extent than that of the Savannah, and its banks are tolerably low. There is some trouble in securing good locations and foundations for dams. The power of the stream is used for only grist- and saw-mills, as will be seen from the table on page 141; and although there are several places where there are shoals with falls of a few feet, some of which have heretofore been utilized, yet there are no very good sites on the stream. The flow of the stream is so variable, and its water-power so small, that estimates of its flow are not necessary.

Little river, South Carolina, is the next stream worth mentioning. It takes its rise in the eastern corner of Anderson county, and flows in a southerly direction, most of its course lying in Abbeville county, entering the Savannah almost on the boundary-line between that county and Edgefield. Its length in a straight line is about 45 miles, and it drains about 530 square miles, receiving as its principal tributary Long Cane creek, from the east or north, which drains an area of about 183 square miles. It is bordered with many fine bottom-lands, which are often overflowed, and the banks, as a rule, are not very high. Its fall is moderate, perhaps about as large as that of the Savannah, or rather greater. Its elevation at the crossing of the Savannah Valley railroad, 3 miles above the Edgefield county-line, is 222 feet; and that of Long Cane creek, at the crossing of the Greenville and Columbia railroad (see map), is 481 feet. It is used for grist- and saw-mills, and has several sites not used, offering good powers. Below the mouth of Long Cane creek there is only one mill, a grist- and saw-mill (and a Clement-attachment cotton factory in course of erection), situated about a mile from the mouth of the river. Above the mouth of Long Cane creek the next power is an unutilized site known as Martin's shoal, 19 miles from Abbeville, and 8 miles above the first mill. The fall is said to amount to 15 feet in 1,500. The bed is rock, and the banks high and precipitous. I am not able to say whether this power is easily available. Above come two grist-mills, with falls of 7 and 14 feet, and then a second site, not used, known as the Trimble shoals, 13 or 14 miles from Abbeville. The shoal is half a mile long, but the fall is not known, although it is said to be considerable. The bed is very rocky, and can be crossed at low-water, by jumping from rock to rock, without wetting one's feet. The banks are said to be very steep, and the construction of a canal would present difficulty. Above this point are only a few small grist- and saw-mills. Long Cane creek, which enters Little river about 5 or 6 miles from its mouth, has more bottom-land than the latter, and probably not so much fall. It is utilized for grist- and saw-mills, and has a few shoals not used, but none of much importance.

The rainfall on the drainage-basin of Little river is about 50 inches—14 in spring, 13 in summer, 9 in autumn, and 14 in winter. I would therefore estimate its flow and that of Long Cane creek as in the table on page 134.

Estimate of flow and power of Little river, South Carolina.

Stream and place.	Drainage area.	Rainfall.					Flow per second.				Horse-power available, gross.*			
		Spring.	Summer.	Autumn.	Winter.	Year.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.*
	Sq. m.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*1 ft. fall.*	*1 ft. fall.*	*1 ft. fall.*	*1 ft. fall.*
Little river at mouth	531	14	13	9	14	50	79	106	450	123	9.0	12.0	51	14.0
Little river above mouth of Long Cane	320	14	13	9	14	50	44	57	282	66	5.0	6.5	32	7.5
Long Cane at mouth	183	14	13	9	14	50	22	28	158	32	2.5	3.2	18	3.6

* See pages 18 to 21.

The next important tributary to the Savannah is Broad river, from Georgia, the largest affluent of the stream. Its headwaters are in Banks and Habersham counties, whence it flows southeast through Franklin and Madison counties, and between Elbert county on its left and Madison and Oglethorpe counties on its right, where it turns to the left and flows nearly east between Elbert county on its left, and Oglethorpe, Wilkes, and Lincoln counties on its right, joining the Savannah on the line between Elbert and Lincoln counties, and at a point about 59 miles above Augusta. Its length along its general course is about 78 miles, and it drains a total area of 1,500 square miles. It is navigable for pole-boats for a distance of 5 miles from its mouth, its width in that distance being about 300 feet. It receives as its principal tributaries the South fork, which enters between Madison and Oglethorpe counties and drains 275 square miles; the Hudson river, which enters in Franklin county and drains 213 square miles; and the Middle fork, which also enters in Franklin county, draining 192 square miles, all three entering from the west or south. The North fork, or main stream, drains an area of 167 square miles above its junction with the Middle fork.

The general character of the drainage-basin is somewhat similar to that of the lower Saluda. The country is rolling, but not rough, except in the extreme upper parts, where it is broken. The soil is, as usual, clay and loam. The flow of the stream is said to be quite variable, and the freshets heavy, overflowing large areas of low ground. The declivity is broken by shoals in various places, but they are generally not of very much importance; only in one case is a very large power produced. Regarding these shoals I was able to obtain very little information, but it is probable that none of them are worth much for power except the single one referred to. The following brief notes comprise all the information I could obtain:

Smith's shoal, about 2 or 3 miles from the mouth of the stream, is not used, the fall being stated to amount to as much as 6 to 10 feet in half a mile, capable of being increased by a dam, with good banks and bed.

Anthony's shoals, about 5 or 6 miles from the mouth, is the finest shoal on the river, and the only one of importance. I was prevented by the inclemency of the weather from visiting this site, so that the following notes are from hearsay. The shoal is situated just above the lower corner of Wilkes county, about 16 miles from Elberton and 20 miles from Washington, the nearest railroad points. It should be mentioned, however, that a road is projected between Augusta and Elberton which will pass close by the shoal, rendering it easily accessible. The fall of the shoal was variously stated at from 25 to 75 feet in a distance of one and a quarter miles. I am inclined to believe that it is in the neighborhood of 40 feet. The descent is continuous for the entire distance over a bed of rock, the channel of the stream being interspersed with islands, and the width varying from about 750 feet at the head to 1,200 feet near the middle and 600 at the foot of the shoal. The rise in freshets is probably small. The banks are favorable on the north side, where it is said that the whole fall could be utilized by a canal. On the south side they are very bluffy on the lower half of the shoal, and the whole fall could not be utilized. The location for mills is safe, and not liable to overflow in high water. Power has been used on the north side for a cotton factory—the Hopewell factory—which was burned some time ago, and on the south side for two grist-mills, only one of which is now in use. At the head of the shoal is a dam of wood and stone, 18 inches high and 500 feet long, entirely across the river, and from it a race 1,200 feet long leads to the grist-mill on the right bank, where the fall is 12 feet. Above the tail-race of this mill a wing-dam of wood and stone, 18 inches high and 160 feet long, extends from the left (north) bank across to an island, and from it a race about a quarter of a mile long leads to the old cotton factory, where the fall is 18 or 20 feet. The fall continues for three-quarters of a mile below the factory, and in this distance there was once a mill on the right bank, not now used. The exact fall below the factory is not known.

The drainage area above this site is about 1,467 square miles, and the rainfall about 55 inches—15 in spring, 14 in summer, 10 in autumn, and 16 in winter. It is greatest in the upper part of the basin. Having no record of gaugings of the river, I have estimated the power as on page 135.

Table of power at Anthony's shoals, Broad river, Georgia.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second.	Horse-power available, gross.	
	Sq. miles.		*Cubic feet.*	*1 foot fall.*	*40 feet fall.*
Minimum	1,467	....	370	42	1,680
Minimum low season			528	60	2,400
Maximum, with storage			1,450	165	6,600
Low season, dry years			600	68	2,720

* See description; probably not less than 40 feet.

The topography of the drainage-basin is such that it would probably be very expensive to secure the maximum with storage. I am unable to state whether a large pond could be secured or not.

This power was stated by every one who had seen it, and with whom I communicated on the subject, to be one of the finest in the vicinity, and easily controlled. The above estimates show that the power is very large. The facilities for transportation are at present poor, but if the projected railroad is built there will be no difficulty on this score. Good building material can be obtained near at hand. I am indebted for much information regarding the site to Mr. John Thompson.*

At Baker's ferry, 4 to 5 miles above Anthony's shoals, there is said to be a natural fall of 3 feet in 600, not used; and 4 or 5 miles farther up there is a mill in Oglethorpe county, near the edge of Wilkes, with a fall of 3 or 4 feet. Above that there is no power below the mouth of the South fork, which enters some 20 miles above Anthony's shoals; and even above the mouth of the South fork, although there are a few small shoals, there are no powers of importance. Mention was made of Dedwiler's shoal, Thicket's Ferry shoal, Moore's old mill, King's Ferry shoal, Murray's shoal, and of a shoal near Franklin springs, none of them used or of any consequence. The water-power of the Broad river, with the exception of that at Anthony's shoal, seems to be of little value.

The South fork, or South Broad, has a few powers worth mentioning. A mile or two above its mouth is Eberhart's mill, at Pogg's shoal, where the fall is considerable. The stream flows over a ledge of rock, and the total fall is said to amount to 80 feet in a distance of a mile. The banks are high, but not bluffy. A log at the head of this shoal turns the water into a race 100 feet long, which conveys it to a grist-mill, where the fall used is between 20 and 30 feet. This shoal is a good one, but the power is small. Four miles above is a similar shoal, a quarter of a mile long, with a fall of some 25 or 30 feet, used by Watson's grist-mill. There are other precipitous falls on small streams in the neighborhood. Hudson river is said to have no power except near its headwaters. Middle Broad river has no mills. Near its mouth the country is said to be very broken, and it is probable that the stream is shoaly for several miles above its junction with the North Broad. Above that the stream has a good deal of bottom-land and low banks along its course, subject to frequent overflow. The North Broad has several mills, but no great falls, the power at the mills being in all cases obtained with high dams. This fork, like the previous one, has generally low banks and large areas of bottom-land overflowed in times of high water. As regards the flow of these streams detailed estimates are not necessary. I would judge that the three forks and the Hudson might be depended upon at their mouths for at least 0.18 to 0.22 cubic foot per second per square mile during the low season of very dry years and 0.26 to 0.32 during the low season of ordinary years. The drainage areas having been previously given, the power can be easily calculated.

The next tributary of the Savannah is Rocky river, which rises in Anderson county, South Carolina, and flows nearly south, entering the Savannah in Abbeville, just at the head of Trotter's shoals. Its length in a straight line is about 40 miles, and its drainage area 241 square miles. It passes within a few miles of Anderson Court-house, and its elevation, where it is crossed by the Greenville and Columbia railroad, about 2 miles east of that place, is 669 feet above tide, while at the crossing of the Savannah Valley railroad, 3 miles below Lowndesville, it is 356 feet. The general character of its drainage-basin is similar to that of Little river, South Carolina, but there are fewer bottoms than on the latter stream, the banks are higher, and the rises more sudden. The stream offers considerable power, but is used only for grist- and saw-mills. The flow is quite variable—more so than that of Little river. The first power on the stream is at the mouth; but from all I could learn the fall is small and the power of little value, although formerly there was a mill there. The stream at this place is about 90 feet wide. The next power above is a grist-mill, with 12 feet fall, 3 miles from the mouth of the stream. Above it are four more mills in Abbeville county, one of which (Burdett's), 5 miles northeast of Lowndesville, is situated on a fine shoal, the fall being stated at 47½ feet in 1,500. The mill uses 31 feet and a small amount of power. There are no important sites not used in Abbeville county. In Anderson county there are three grist-mills with small falls. They are troubled sometimes for want of water, but the dams are not tight. There are also two sites not used in this county: the lowest one, not far from the county-line, known as Lee's shoal, with a natural fall of 10 feet in a short distance, capable of

* In a letter of recent date Mr. Thompson writes that he has measured the fall with a spirit-level and finds it to be over 70 feet.

being increased to 15; and the upper one, known as High shoals, 6 miles above the first, a mile above the mouth of Broadaway creek and 5 miles from Anderson Court-house, with 38 feet fall in 200 yards, not capable of being increased.

The remaining tributaries of the Savannah below the junction of the Seneca and Tugaloo are not of much importance. Beaverdam creek, from Elbert county, Georgia, which enters nearly opposite the Rocky river, is well utilized by grist-mills, there being no fewer than nine mills on it, although its length is only about 30 miles in a straight line, and its drainage area 185 square miles. The mills have falls of from 12 to 20 feet. At Gray's mill, the second as the stream is ascended, although only about 10 feet fall is used, the total fall of the shoal is stated to be nearly 25 feet in a distance of a mile. At Flat shoals, some 25 miles from the mouth of the stream, there is a fall of about 18 feet, not used, and at several other places there is unutilized power. Near its mouth the stream will run 2 pair of stones all the year with a fall of 10 feet and a good motor. The other tributaries to the Savannah—Coldwater and Cedar creeks, from Georgia, and Little and Big Generostee creeks, from South Carolina—all have shoals and afford small powers. The last-named drains about 75 square miles, and has two shoals, known as Hard-Scrabble and Hamilton shoals, the former only a quarter of a mile from the mouth, with an available fall of 16 feet at the mill and considerable fall above and below not utilized.

THE TUGALOO RIVER.

This stream, one of the two headwaters of the Savannah, is formed on the line between Georgia and South Carolina by the union of the Tallulah and Chatuga rivers, the former of which rises in Rabun county, Georgia, and Macon county, North Carolina, and flows in a general southeasterly direction through Rabun county, draining an area of 155 square miles, and the latter of which rises in Jackson county, North Carolina, and flows in a southwesterly direction, forming the boundary-line between Georgia and South Carolina, and draining an area of about 294 square miles. The Tugaloo flows in a southeasterly direction between the two states, its length being about 35 miles in a straight line and 49 by the course of the stream, and its total drainage area at its mouth being 870 square miles, or 421 square miles exclusive of the Chatuga and the Tallulah. Its principal tributaries are: from South Carolina, Big Beaverdam, Choestoe, and Chauga creeks, the last draining 71 square miles; and from Georgia, Shoal, Toccoa, and Panther creeks, all small streams.

The drainage-basin of the Tugaloo river proper has no peculiarities that have not been already referred to in describing the middle and western divisions of the southern Atlantic water-shed in the introduction. There is some limestone in the upper part of the basin. The river flows over a rocky bed, broken in places by shoals, but by none of importance except in the last 8 miles of its course. Its declivity is gradual, and its water-power not of much value. It is bordered by considerable tracts of fertile bottom-land, sometimes overflowed, although the freshets were not stated to be very violent. The elevation of the stream at the crossing of the Atlanta and Charlotte Air-line railroad, about 36½ miles from its mouth, is about 638 feet, while that of its mouth is 400 feet; so that the fall is 238 feet in 36½ miles, or at the rate of 6½ feet per mile. The rainfall in the whole drainage-basin is about 56 inches—15 in spring, 15 in summer, 10 in autumn, and 16 in winter. There are no records of gaugings. The stream is not very accessible, as will be seen from the map, the nearest railroad point to the mouth being Hartwell, 5 miles distant, while the Atlanta and Charlotte Air-line railroad crosses the river almost at right angles.

There is not a mill on the stream, and there are only a few places suitable for power. The first site is Hatton's shoal, one and a half miles long, with a fall of 39 feet, as ascertained by the barometer.* The foot of this shoal is about 2½ miles above the mouth of the stream, and its head is just below the mouth of Beaverdam creek. The width of the stream at the foot is 150 feet, but in the course of a quarter of a mile it widens to 1,400 feet, and the water is very shallow. At one point there is a perpendicular fall of 2 feet, but the fall is, with this exception, quite gradual. The country is quite broken from the mouth of the river up to above the shoal, and at the shoal itself the banks are quite high, especially on the South Carolina side, so that a canal could be built only with great difficulty on this side. The Georgia side is more favorable, and could probably be canaled; but I had no opportunity to examine the site thoroughly. There was once a mill near the foot of the shoal on the Georgia side with a wing-dam and a fall of 5 or 6 feet, the banks being tolerably low on that side for half a mile or so. The drainage area above the shoal being about 845 square miles, I have estimated the power as in the table, p. 137. It must be remarked, however, that the fall, as determined by the barometer, is so liable to error, that little dependence is to be placed on the result; and it was thought by persons acquainted with the river that the fall does not amount to 39 feet.

* *Annual Report of Chief of Engineers*, 1879, p. 754.

Table of power on Hatton's shoals, Tugaloo river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*39 feet fall.*
Minimum	845	*39	211	24	936
Minimum low season			255	29	1,131
Maximum, with storage			925	105	4,095
Low season, dry years			290	33	1,287

* As determined by barometer.

The next shoal is Guest's, the fall being stated at 17 feet in a mile, as found by the barometer. This shoal was stated to be of little value for water-power. In the table on page 131 is an estimate of the power, assuming the fall at 17 feet.

As the mountains are approached the fall of the stream becomes more rapid, and for a mile and a half below the junction of the Chatuga and the Tallulah the fall is at the rate of 30 feet to the mile.* The country is rough here, the banks abrupt, and the site inaccessible. Its value for manufacturing is probably small.

The width of the Tugaloo is 310 yards at its mouth, 50 yards above Guest's shoal, 40 yards at the crossing of the Atlanta and Charlotte Air-line railroad, and 150 yards at the junction of the Chatuga and the Tallulah.

There is some power on a few of the tributaries of the Tugaloo, although it is not extensive. Little Beaverdam creek, which enters at the mouth from South Carolina, has one power at its mouth, where there used to be a yarn-mill, using the Clement attachment, but the power is now used for a saw- and grist-mill. The fall used is 20 feet, but it could be increased to 25 or 30 feet by raising the dam. The power, however, is very small, not over 25 to 30 horse-power in a low season. Big Beaverdam creek, which enters at the head of Hatton's shoals, has a large fall near the mouth, said to be 65 feet or more in a mile, and at one place almost 30 feet in one pitch. This stream, however, is also small, and in dry weather will give probably not over one horse-power per foot fall. Shoal creek, Georgia, enters 10 miles above Guest's shoal, and has several shoals and mills, including one cotton-mill, a mile or so from the mouth, using 26 feet fall and 15 or 20 horse-power. The falls on the creek are large, Parker's grist-mill having a fall of 16 feet, and his wool-carding mill a fall of 20 feet. Choestoe creek, from South Carolina, is a similar stream, but its water-power is not so extensive. Chauga creek, from South Carolina, is a more considerable stream, and enters 2¼ miles below the railroad crossing. It drains about 71 square miles, according to the map used, which, however, is inaccurate. The stream has little bottom-land, and is subject to heavy freshets, which sometimes rise very suddenly. The first power on it is Gilmer's mill, half a mile above the railroad and one and a half miles from Fort Madison, with a fall of about 12 feet. Farther up are other sites, and near its head is a fall of 60 feet in one-fourth of a mile. On its upper waters are a number of precipitous descents, but of no value for water-power. One little tributary to the Tugaloo above the Chauga has a perpendicular fall of 60 feet near its mouth; and on Toccoa creek, a very small stream, draining 25 or 30 square miles, are the famous Toccoa falls, where the stream falls 183 feet perpendicularly. The place is much frequented by tourists, but the water-power is of no practical value.

The Chatuga river is a mountain stream, with considerable fall, and no doubt numerous sites for power, but nothing could be learned of any particular ones. Its flow is subject to great fluctuations, and its inaccessibility renders its water-power of small value. It is 150 yards wide at its mouth, with very precipitous banks, and the surrounding hills are from 800 to 1,000 feet high.

The Tallulah river is similar in character to the Chatuga. The Tallulah falls, about 15 miles from Toccoa city, on the railroad, and 10 miles above the mouth of the stream, is a noted place of resort, and one of the wildest and most picturesque spots in the state. The stream flows through a narrow gorge, with very high banks, and descends in a series of pitches (four of which have perpendicular heights of from 50 to 80 feet), falling, it is said, 500 or 600 feet in a mile. Its width varies from 15 to 100 feet. At the head and the foot of the falls the banks are of ordinary height, but in the intermediate distance they are from 200 to 800 feet high, rising almost perpendicularly from the bed of the stream, and rendering the utilization of the water-power quite impracticable. There are, in fact, only two or three places where it is at all possible to descend to the bed of the stream, and these are the beds of small rivulets emptying into the river.† The drainage area above these falls is about 147 square miles, so that I would estimate the flow in the low season of ordinary years at about 44 cubic feet per second, corresponding to 5 horse-power per foot fall. The theoretically available power is therefore large, but practically the power is of no value. The romantic beauty and wildness of this place is said to be beyond description, and its praises are sounded by all who have visited it.

Before leaving the Tugaloo river, it is to be mentioned that its headwaters are not far distant from those of the Hiawassee, a navigable branch of the Tennessee, and that it is proposed to open a line of water communication between the Atlantic coast and the West by connecting the two streams by a canal.

* *Annual Report of Chief of Engineers*, 1879, p. 755.

† White's statistics of the state of Georgia, 1849.

THE SENECA RIVER.

This river, with the Tugaloo, makes up the Savannah, and, like so many streams in this part of the country, is formed by the junction of two smaller streams—the Keowee river and Twelve-Mile creek (or river)—which unite on the line between Oconee and Pickens counties, South Carolina. The Keowee has its headwaters in the mountains of Jackson county, North Carolina, and pursues a southerly course between the two counties above mentioned, draining an area of about 405 square miles, while Twelve-Mile creek rises in the northern part of Pickens county, and flows a little west of south, draining about 118 square miles. From the junction of these two the Seneca flows in a general southerly direction, its length being nearly 20 miles in a straight line, and the total area drained being 908 square miles, or 385 square miles exclusive of the basins of the two headwaters. It receives as its principal tributaries: from the east, Deep creek, formed by the union of Twenty-three Mile and Twenty-six Mile creeks, and draining 150 square miles, and Eighteen-Mile creek, draining 49 square miles; and from the west, Conneross creek, draining about 93 square miles. The character of the drainage-basin is similar to that of the Tugaloo, except that there are perhaps more bottom-lands, the banks being generally rather low. It is said not to rise so suddenly or so high as the Tugaloo; and, like that stream, it has not a single mill. The stream is crossed nearly at right-angles just below the junction of its headwaters by the Atlanta and Charlotte Air-line railroad, and several miles below by the Blue Ridge railroad. The fall of the stream averages between 7.3 and 8.75 feet per mile, if its length is assumed at 25 or 30 miles. Its elevation at its head is 619 feet, and at its mouth 400. The rainfall is the same as in the basin of the Tugaloo.

There are several small shoals on the stream, but only one of importance. There is a small shoal at the mouth, with a fall of 3 or 4 feet, capable of being increased, and another similar one at Earle's bridge, 4½ miles above; but the principal one is Portman's shoal, 5 miles from the mouth, just below the mouth of Eighteen-Mile creek, and just above the mouth of Deep creek, and of which the shoal at Earle's bridge is simply a continuation. This shoal is the most important one in the vicinity, and is now entirely unimproved, although some years ago a small amount of power was used for iron works. There is said to be an abundance of high-grade iron ore in the vicinity, but a great scarcity of fuel, and no lime within ten miles. For my information regarding these shoals I am indebted to Major T. B. Lee, civil and hydraulic engineer, of Anderson, who owns the shoals, or a part of them. The total fall is about 60 feet in a distance of 2 miles, but there is no prominent fall, except at the lower end, where there is in one place a natural fall of 9 feet in a short distance. A dam 6 feet high and a race of 500 yards long would give a fall of 20 feet with a favorable building location, and a dam 10 feet high, with a race of 800 yards long, would afford a fall of 30 feet. The dam would be about 600 feet long, and there is in the immediate vicinity an abundance of material for building. The bed of the stream is rock and gravel, and the banks favorable for canals and for building, except in a few places, where the banks are bluffy. This shoal is 10 miles from Anderson and 6 miles from the Blue Ridge railroad. A new railroad is said to be projected, which will pass less than a mile from the place.

The drainage area above being about 740 square miles, I have estimated the power as in the following table:

Table of flow and power at Portman's shoals.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	*60 feet fall.*
Minimum	740	60	189	21.5	430	1,290
Minimum low season			250	28.4	570	1,700
Maximum, with storage			825	93.7	1,875	5,620
Low season, dry years			286	32.5	650	1,950

It must be especially mentioned here that Major Lee, who is an engineer of eminence and of long experience, and well acquainted with the country, writes that "1,000 cubic feet of water per second all the year round—two-thirds of the year double this flow—is to be had". I do not, however, understand this result to be based on a continued series of gaugings, but I have thought best to call attention to it, and to the differences between this and the estimates in the table above. I have in many places sufficiently emphasized the fact that the latter must be liable to many errors; and I must further state here that just in this part of the state of South Carolina I have discovered a number of errors in the map I have used. I can scarcely think, however, that the measurement of the drainage area is in error by more than 10 per cent., and even if my estimates are increased by that fraction they will still be very much less than Major Lee's. As for my method of making the calculation, I have already said enough in the introduction, and on pages 107 and 108. Major Lee states that there are facilities on the upper Seneca, as well as on the Saluda, for the construction of storage-reservoirs. It is therefore possible that the maximum power, with storage, might be rendered practically available, and it might even be possible to concentrate

the power to some extent into working hours. This power, situated in a fine cotton-growing country (Anderson county produced last year 40,000 bales, according to Major Lee), having a healthy and salubrious climate, is worthy the attention of capitalists.

Above Portman's shoals there are a few small shoals on the Seneca, but none of value. Hen shoal, sometimes spoken of, has, according to Major Lee, only a fall of a few feet. It is just above the mouth of the Conneross, 6 miles from Pendleton and 11 miles from Seneca.

Estimates of the total theoretical power of the Seneca, and other streams tributary to the Savannah, are not given, because they would have no value, on account of such a small proportion of that power being practically available.

TRIBUTARIES OF THE SENECA RIVER.

The power of the tributaries of the Seneca is of more importance than that of the main stream if Portman's shoals are not considered. The first tributary is Deep creek, which enters just below the shoal just named, draining 150 square miles, and formed by the union of Twenty-three Mile and Twenty-six Mile creeks. It is a deep and sluggish stream, with no power whatever. Twenty-six Mile creek is a small stream, entirely in Anderson county, and drains some 50 square miles. Above Centreville it is very flat, with small fall and low banks. The bed is sand, mud, and gravel, the banks clay, and the course of the stream tortuous. At and near Centreville, which is 2 miles from its mouth (junction with Twenty-three Mile creek), the stream falls quite suddenly, and for the rest of its course flows considerably below the general level of the surrounding country. There are two grist-mills on the stream above Centreville, and one at that place using a fall of 14 feet; but the available fall is said to amount to 26 feet, which could be utilized by building a dam higher up. The place is favorable for building, and the power is a good one, though small. The tributaries near Centreville have large falls near their mouths; for example, on Emery creek there is a fall of 60 feet, and on Hurricane creek a similar one. Twenty-three Mile creek is considerably larger than the last, draining 87 square miles or thereabout. It has its sources in Pickens and Anderson counties. The upper part is flat, like the stream last described, and its general character is the same; while on the lower part there are several powers. Descending the stream, the first power is at Pendleton cotton factory, where the fall is 25 to 30 feet. I have received no information regarding the power, but it probably does not exceed 60 horse-power.* Below it is Burns' shoal, not used, where a dam 15 or 20 feet high could be built without interfering with the factory above, and that amount of fall utilized. Below is a grist-mill, with a fall of 6 feet, although 14 could be got, with a good building-place. The country is high and rocky on each side. The lowest power on the stream is a mill about three-fourths of a mile from its mouth, where there is a natural fall in the stream of 35 feet or more in 300 yards, but not a very favorable place to build, and difficult of access. The stream is very rapid, and shut in by hills on both sides. This fall corresponds to Portman's shoal on the Seneca, and is probably caused by the same ledge of rocks.

The next tributary is Eighteen-Mile creek, which enters the Seneca just above Portman's shoal. It drains about 50 square miles, corresponds in general character with the two streams last described, and has no power except near its mouth, where there is a mill with a fall of 12 feet, and nearly twice as much available. It is not a noteworthy site.

Conneross creek, from the west, is the next tributary. It is about 22 miles long in a straight line, and drains an area of about 93 square miles, all in Oconee county, except a few square miles near the mouth. Its drainage-basin is long and narrow, and its fall rapid. Its bed is rock, its banks generally good, and it is in all respects a better stream for water-power than the tributaries thus far named, except that it may be subject to heavier freshets. The lowest shoal on the stream is owned by Mr. J. B. Sitton, of Pendleton, and is 5 or 6 miles from the mouth. It is utilized by a grist- and saw-mill, using 18½ feet fall, with a dam 30 inches high and a race 80 feet long. The total available fall is stated at 31 feet, over a solid rock ledge—there being two falls, the lower one only being used, and the upper one being only 250 or 300 feet above. The stream is about 70 feet wide, and the banks favorable. This shoal is favorably located, and is 5 miles from Seneca, on the Atlanta and Charlotte Air-line railroad.

A mile and a half above is another large shoal, known as Swepson's or High shoals, also 5 miles from Seneca. It was formerly known as Anderson's mill-site. The fall is very large, amounting, it is said, to 50 feet or more in a few hundred yards. It is said, however, to be difficult to utilize, on account of the high bluffs on each side. A large reservoir could be formed above the shoals, but not without overflowing much good land. Above this there are no large falls, except far up the stream, where there is in one place a fall of 26 feet, and probably there are others. Major Lee states that Conneross creek is a remarkably constant stream, varying very little in flow from season to season. Estimates of power are omitted as unnecessary. If desired, they may be arrived at by comparing with those given for some of the following streams.

Twelve-Mile creek, one of those streams which unite to form the Seneca, is comprised entirely in Pickens county, and is formed by the union of three forks. As already mentioned, it drains an area of 118 square miles. Its basin is mountainous in the upper part, and the three forks have large falls, but are very small streams. After leaving the

* Power stated at 40 horse-power in statistics of cotton-mills.

mountains, the stream flows through a level country and resembles Eighteen-Mile, Twenty-three Mile, and Twenty-six Mile creeks, only in this case the country is not quite so flat as in the others, and the banks are generally higher and not so subject to overflow. The stream is subject to heavy freshets and to more sudden fluctuations than the others; its bed and banks are rockier, and its fall greater. Toward the mouth of the stream the fall is rapid, and there are several powers worth mentioning. The first one met with in ascending the stream is Winn's, not improved, about 2 or 3 miles from Central, on the Atlanta and Charlotte Air-line railroad. This shoal has a length of about one and a quarter to one and a half miles, with an almost continuous fall. In the lower half mile the fall is not less than 25 feet, as ascertained with a pocket-level, and it is said to continue at the same rate to the head. The shoal is, however, confined between steep banks, which would present difficulty in canaling, although a canal would be practicable on the left bank. There is building room at the foot of the shoal. I was unable to examine it from head to foot, but I think that a large fall could be obtained here, although it might be best to obtain it by a dam near the foot and with a short canal. The left bank is low for 100 feet from the river, but this part is liable to overflow to some extent, and further back the bank is exceedingly steep. The river is about 125 feet wide, and the bottom is favorable for dams; so that I think there would be no difficulty in developing the power. At the head of the shoal there is an abrupt fall of 10 feet, known as Clayton's shoals, used by Robertson's saw- and grist-mill, about three miles from Central. The dam is only 1½ feet high and 175 feet long, diagonally across the stream, and the banks are favorable and safe. The fall continues for one-eighth mile above the dam, which could be made 10 feet high, and a fall of 20 feet used, if desired. The fall occurs over a ledge of gneiss-rock, and the power is an excellent one, though small. It should be mentioned that about three-fourths of a mile or so below is a place known as the "narrows", where the stream rushes swiftly between steep banks, and is very narrow.

I subjoin an estimate of the power at this place, based on analogy, as an approximation:

Table of flow and power of Twelve-Mile creek.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power, gross.	Remarks.
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	
Minimum	118	(*)	15	1.70	Drainage area given is that of the stream at its mouth—too large for the shoal just described.
Minimum low season			21	2.40	
Maximum, with storage			135	15.40	
Low season, dry years			24	2.75	

* Probably in all not less than 50 to 60.

If the stream is fed extensively by springs, its flow will be larger in dry seasons. In ordinary years it would afford in the low season, according to the above estimate, 3½ horse-power per foot, and two or three times as much for nine months of the year. It may be remarked that the flow of Conneross creek would probably not differ much from that of the one under consideration.

Half a mile above Robertson's mill there is a small shoal with a fall of about 5 feet, and then the stream is sluggish for over a mile, when we come to a second shoal, extending for a quarter of a mile or more, at the head of which is Hunter's mill, with a dam 5 or 6 feet high and a fall of 11 feet, and no race. Above this there are no shoals for 8 miles, where the stream is so small that it is not necessary to particularize further. The estimates given above are, I think, rather too small, and it would seem as though the streams in this vicinity were subject to smaller variations in volume than would be expected. I have already referred to the constant flow of Conneross creek, and it is probable that this stream is similar in that respect. I was told at Hunter's mill that they could run four pair of stones all the time. Data, however, are entirely wanting for an accurate estimate.

The Keowee river, which, with Twelve-Mile creek, forms the Seneca, has its sources among the mountains, and is formed by the union of the Toxaway and the Big Estatoe creeks in the northern part of Pickens and Oconee counties. It flows south, and drains a total area of 405 square miles. The upper part of the basin abounds in precipitous falls and cataracts of great beauty, although valueless for water-power. The Whitewater creek is so named on account of its numerous cascades; and at one place there is a fall of 600 feet in 300 yards,* with numerous smaller falls. On another stream in the vicinity there is a fall greater in height than that of Niagara in one pitch.* Another small branch of the Keowee has two falls of nearly 50 feet, each close together, and 200 yards below a fall of 80 feet. Another has a perpendicular fall of 130 feet. The Keowee itself—whose name is said to mean *clear water*—is a beautiful stream, flowing with a gradual fall over a rock bed, and draining a very picturesque valley. It is entirely unutilized for power, and I was unable to learn of any particular sites, although there must be some. Among its tributaries, many of which are utilized to some extent, the principal one is Little river, a stream rising in the northern part of Oconee county, only a few miles from the Chatuga river, and flowing a little east of south for a distance of 18 or 20 miles, draining about 140 square miles. It is a good stream for power, and has several falls and mills in various places. The rainfall on all this upper part of South Carolina is about the same

* MILLS: Statistics of South Carolina.

as on the drainage-basin of the Tugaloo, viz, 56 inches—15 in spring and summer, 10 in autumn, and 16 in winter. I would therefore estimate the flow of the Little river at its mouth about as follows:

Table of flow and power of Little river.

State of flow (see pages 18 to 21).	Drainage area.	Flow per second.	Horse-power, gross.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*
Minimum	140	20	2.3
Minimum low season		30	3.4
Maximum, with storage		168	19.1
Low season, dry years		35	4.0

The first power on the stream is Seaburn's shoal, a mile from the railroad and the mouth of the stream, and three or four miles from Seneca. It was formerly used by a saw-mill, but is now unimproved. The fall is 13½ feet, which could be used with a canal 800 feet long, very easy to cut. The proper location for a mill is on the left bank, at the foot of the shoal, the right bank being steep. Just above this shoal Cain creek, the principal tributary of Little river, enters. Less than a mile above is a second unutilized shoal, but I am unable to state the fall. The next power is High shoals, a beautiful shoal, where the river falls over a ledge of solid gneiss-rock, descending 24 feet almost perpendicularly, with rapids above for some distance, and a total fall of about 35 feet. The banks are high, but very favorable for building, and the power is in all respects an excellent one. It is used by a tannery on the left bank, utilizing a fall of 14 feet and 15 to 16 horse-power, with a flume 500 feet long and 2 feet square, and an overshot-wheel, and on the right bank by a saw- and grist-mill and cotton-gin, using 10 horse-power and 24 feet fall. The dam is of wood, 2 to 3 feet high, and 125 to 150 feet long, extending in a broken line entirely across the stream. Just above this is a fall of 6 feet in 500, and a 3-foot dam at the upper end of this last shoal, it is said, would back up the water a mile or over. The power is 9 miles from Seneca, 10 miles from Walhalla, and is owned by Sligh & Woodin, High Falls post-office. The drainage area above this shoal being not over 60 or 70 square miles, I should estimate the power in the low-season of dry and ordinary years at 1.2 horse-power and 1½ horse-power per foot fall respectively, and three times as much during nine months. But as my measurements of drainage areas, especially of so small ones, are liable to considerable error, these figures are not very valuable. Above these falls there are several others, one with 14 feet fall, used by a tannery; two others, 150 yards apart, with falls of 20 and 16 feet respectively, and another right at the foot of the mountains with a fall of 50 or 60 feet.

Cain creek, the principal tributary of Little river, drains 50 or 60 square miles, and has one shoal, not used, with 40 feet fall—the Schroeder shoal.

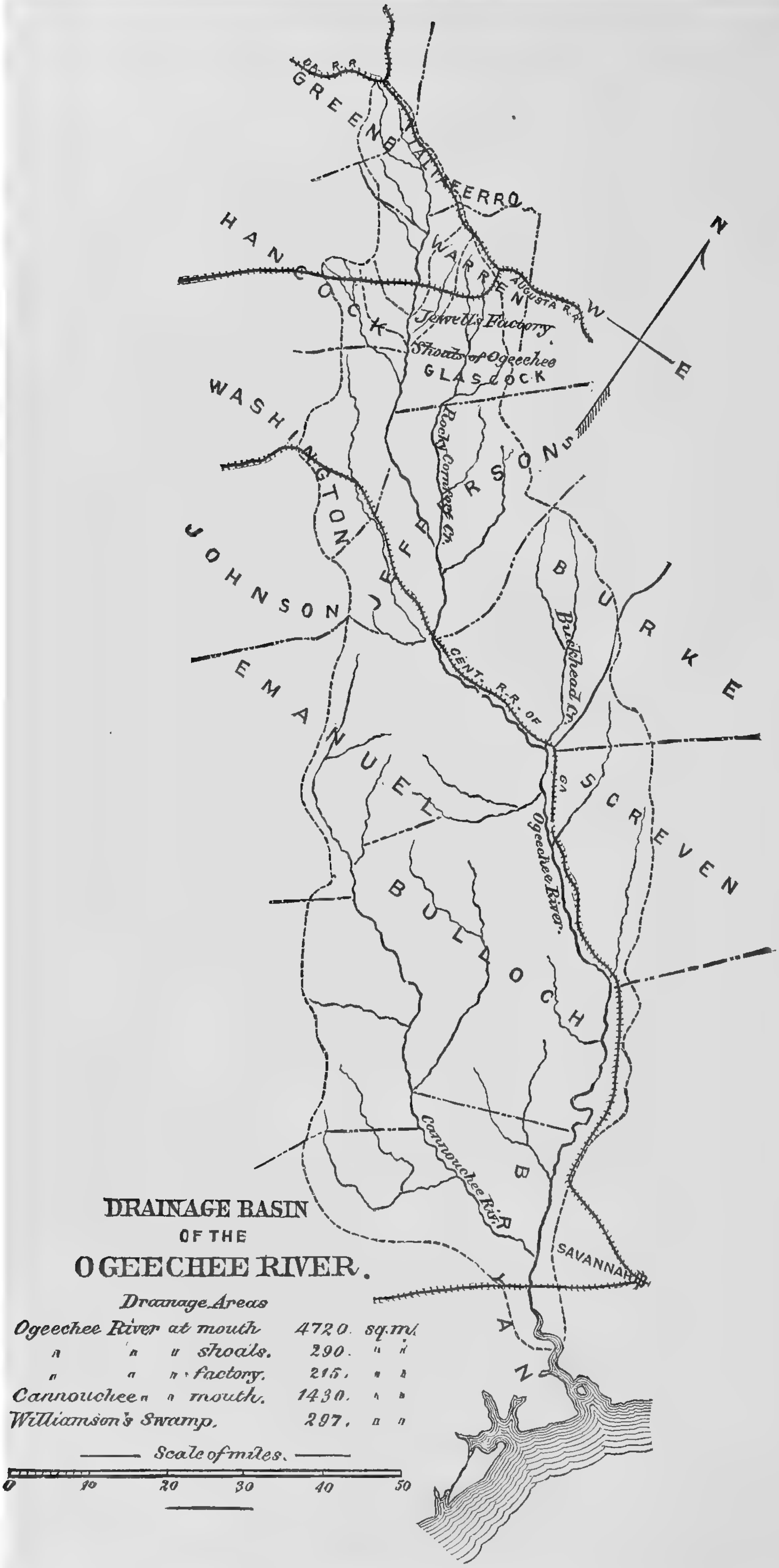
Table of utilized power on the Savannah river.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Savannah	Atlantic ocean	Georgia	Richmond	Miscellaneous*	15	.....	3,650
Do	do	South Carolina	Abbeville	Flour and grist	1	12.0	8
Do	do	do	do	Saw	1	8.0	8
Do	do	do	Anderson	Woolen	1	12.0	20
Do	do	Georgia	Lincoln	Flour and grist	3	14.5	32
Do	do	do	Elbert	do	2	19.0	115
Tributaries of	Savannah	do	Effingham	Saw	1	6.0	20
Do	do	do	Burke	Flour and grist	8	72.0	96
Do	do	do	Richmond	do	11	125.0	190
Do	do	do	do	Saw	8	100.0	209
Do	do	do	do	Cotton factory	1	9.0	50
Do	do	do	do	Woolen	1	9.0	45
Little river	do	do	Lincoln	Saw	3	24.0	45
Do	do	do	do	Flour and grist	4	30.0	60
Do	do	do	McDuffie	do	1	9.0	60
Do	do	do	Wilkes	do	1	8.0	8
Do	do	do	Warren	do	1	8.0	30
Do	do	do	Greene	Saw and grist	1	14.0	15
Other tributaries to	do	do	Columbia	Flour and grist	5	69.0	91
Do	do	do	do	Saw	1	10.0	25
Do	do	do	McDuffie	do	3	......	....
Do	do	do	do	Flour and grist	7	127.0	152
Do	do	do	Warren	do	1	20.0	15
Do	do	do	do	Saw	1	12.0	12

* See Augusta.

Table of utilized power on the Savannah river—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Broad river and tributaries	Savannah	Georgia	Oglethorpe	Flour and grist	10	195.0	175
Do	do	do	Madison	do	10	145.0	281
Do	do	do	do	Saw	5	61.0	64
Do	do	do	Elbert	Flour and grist	3	44.0	39
Do	do	do	Franklin	do	9	......	163
Do	do	do	do	Saw	4	56.0	54
Do	do	do	do	Cotton-gin	6	83.0	53
Do	do	do	Banks	Saw	1	18.0	20
Do	do	do	do	Flour and grist	12	169.0	279
Other tributaries of	do	do	Wilkes	do	7	85.0	75
Do	do	do	Elbert	do	6	73.0	134
Do	do	do	do	Saw	1	14.0	12
Do	do	do	Hart	Flour and grist	11	194 0	156
Do	do	do	do	Saw	1	14.0	15
Do	do	do	do	Cotton-gin	8	99.0	70
Tributaries of	Tugaloo	do	do	Saw	1	30.0	10
Do	do	do	do	Flour and grist	2	27.0	45
Do	do	do	do	Cotton factory	1	26.0	20
Do	do	do	do	Wool-carding	1	20.0	44
Do	do	do	Habersham	Flour and grist	4	47.0	46
Do	do	do	do	Leather	1	16.0	6
Do	do	do	do	Saw	3	46.0	78
Do	do	do	do	Woolen	1	......	6
Do	do	do	Rabun	Saw	1	14.0	8
Horse creek	Savannah	South Carolina	Aiken	Paper	1	38.0	500
Do	do	do	do	Cotton factory	3	115.0	1,200
Do	do	do	do	Flour and grist	2	26.0	40
Do	do	do	do	Stoneware	2	24.0	67
Little river	do	do	Abbeville	Flour and grist	3	33.0	83
Do	do	do	do	Saw	1	9.0	15
Do	do	do	do	Flour and grist	1	7.0	12
Rocky river	do	do	do	do	5	......	112
Do	do	do	do	Saw	4	37.0	53
Do	do	do	Anderson	Flour and grist	3	62.0	69
Other tributaries of	do	do	Barnwell	do	6	54.0	80
Do	do	do	do	Saw	1	8.0	20
Do	do	do	do	Cotton-gin	4	36.0	43
Do	do	do	Aiken	do	3	23.0	32
Do	do	do	do	Saw	6	63.0	122
Do	do	do	do	Cotton yarn	1	......	......
Do	do	do	do	Flour and grist	15	144.0	296
Do	do	do	Edgefield	do	21	......	465
Do	do	do	do	Saw	2	19.0	32
Do	do	do	Abbeville	do	2	16.0	25
Do	do	do	do	Flour and grist	16	210.0	267
Do	do	do	Anderson	do	13	195.0	149
Do	do	do	do	Saw	5	124.0	66
Do	Seneca	do	do	do	4	56.0	34
Do	do	do	do	Flour and grist	9	175.0	135
Do	do	do	do	Cotton-gin	8	......	......
Do	do	do	do	Cotton factory	1	26.0	40
Do	do	do	Oconee	Woolen	2	......	18
Do	Tugaloo	do	Anderson	Cotton-gin	5	94.0	72
Do	do	do	do	Flour and grist	5	87.0	106
Do	do	do	do	Saw	2	22.0	35
Do	do	do	Oconee	Flour and grist	7	155.0	80
Do	do	do	do	Saw	1	25.0	10
Do	do	do	do	Cotton factory	1	21.5	10
Do	Seneca	do	do	Saw	3	48.0	45
Do	do	do	do	Leather	3	54.0	42
Do	do	do	do	Wheelwright	1	16,0	7
Do	do	do	do	Flour and grist	16	287.0	226
Do	do	do	Pickens	do	14	277.0	211
Do	do	do	do	Saw	4	81.0	60
Do	do	do	do	Cotton-gin	9	163.0	130


DRAINAGE BASIN
OF THE
OGEECHEE RIVER.
Drainage Areas
Ogeechee River at mouth 4720. sq.mi.
" " " shoals. 290. " "
" " " factory. 215. " "
Cannouchee " " mouth. 1430. " "
Williamson's Swamp. 297. " "
Scale of miles.
0 10 20 30 40 50
GA. R.R.
GREENE
TALIAFERRO
HANCOCK
WARREN
AUGUSTA R.R.
Jewell's Factory.
Shoals of Ogeechee
GLASCOCK
WASHINGTON
JEFFERSON
Rocky Comfort Cr.
JOHNSON
BURKE
Brushy Cr.
CENT. R.R. OF GA.
EMANUEL
SCREVEN
Ogeechee River.
BULLOCH
Cannouchee Riv.
BRYAN
SAVANNAH
N
W
E

X.—THE OGEECHEE RIVER AND TRIBUTARIES.

THE OGEECHEE RIVER.

This stream, which is the next one south of the Savannah that has any water-power worth mentioning, rises in Greene county, Georgia, and flows southeast through Taliaferro; then between Warren and Glascock on its left, and Hancock and Washington on its right; thence through Jefferson, finally forming the boundary-line between Burke, Screven, Effingham, and Chatham on its left, and Emanuel, Bulloch, and Bryan on its right, and emptying into the Atlantic about 16 miles below the mouth of the Savannah. Its length in a straight line is about 160 or 170 miles, and it drains a total area of 4,720 square miles. Of this drainage area, however, by far the greater part lies below the fall-line, and offers no water-power, except here and there on a sand-hill stream. The river crosses the fall-line between Hancock and Glascock counties, and below that point the general character of the drainage-basin corresponds so closely to that of the Savannah below Augusta, of the Santee, or of the Pee Dee below Cheraw, that it need not be described. Above the fall-line the river flows through a rolling and hilly country, the bed being rock, overlaid between the shoals by sand, gravel, and clay. The bottoms are said to be narrow. The elevation of the stream at the crossing of the Macon and Augusta railroad, at Mayfield, about 8 miles above the fall-line, is 270 feet, so that the fall from that point to the mouth will average about 1.6 feet per mile. The fall below the fall-line will probably not average 1 foot per mile, and the stream could probably be made navigable for some distance. It is said that boats used to ascend the river as far as Georgetown, 4 miles below the fall-line. At present the stream is navigable for a distance of 25 miles from its mouth for boats drawing 16 feet, and for a distance of 35 miles from its mouth for boats drawing 5 feet. The average annual rainfall on the drainage-basin above the fall-line is 49 or 50 inches, of which 11 fall in spring, 14 in summer, 10 in autumn, and 14 in winter.

The first power on the stream is at the fall-line, known as the Shoals of Ogeechee. They are situated 8½ miles from Mayfield, which is the nearest railroad point, and are above the mouth of the Little Ogeechee. The power is utilized by a grist- and saw-mill, with a wooden-frame dam about 225 feet long and 8 or 9 feet high, backing the water 1½ miles, with an average width of 150 feet. The race is 300 feet long, the fall utilized 18 feet, and the power perhaps 30 to 40 horse-power, which can only be obtained ten months of the year on account of leakage. The shoal is of solid rock, and the total available fall is 21 or 22 feet at low water. The drainage area above the shoal being about 290 square miles, I have estimated the power as follows:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	21 *feet fall.*
Minimum	290	21	25	2.8	50	59
Minimum low season			35	4.0	72	84
Maximum, with storage			250	28.4	511	596
Low season, dry years			40	4.5	81	94

Four miles above is D. A. Jewell's cotton factory, 4½ miles from Mayfield. The dam is a wooden-frame dam, composed of triangular frames set up and down the stream, tied together and planked over on the sloping up-stream side, and is 280 feet long and 15 feet high, 50 feet at one end being of stone. It backs the water a mile, with an average width of 150 feet, and the fall at the factory, which has no head-race of any length, is 16 feet. The power utilized is 150 horse-power, which can only be obtained eight months of the year, the average during the remaining four months being two-thirds or three-fourths, and the water gets so low at times that the wheels are stopped. During the low season, steam-power is put on to the extent of 125 horse-power. The mill is run about 12 hours in summer out of the 24, and there is no waste at night; and, in fact, the pond does not fill up in one night. I have estimated the power at this place as follows:

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	1 *foot fall.*	16 *feet fall.*
Minimum	215	16	17	1.9	30
Minimum low season			25	2.8	45
Maximum, with storage			189	21.5	340
Low season, dry years			30	3.4	54

The stream is said to be very variable in its flow, and to get very low in summer. Its absolute minimum is probably below that given above. Mr. Jewell states that he stopped eight days once, and during that entire time his pond only rose a few inches. According to the above estimate, during nine months of an ordinary year about 180 horse-power gross would be obtained, or about 130 horse-power net, which is perhaps a little too high.

Above the factory are several small grist- and saw-mills, most of which have to stop in summer. There are no sites not used.

The tributaries of the stream are of no consequence. On Little Ogeechee there are two sites, both used at one time, but now abandoned. The stream is small, draining only 55 square miles.

Table of power utilized on the Ogeechee river.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Fall used.	Horse-power used, net.
						Feet.	
Ogeechee river	Atlantic	Georgia	Warren	Flour and grist	2	20	30
Do	do	do	Hancock	do	2	13	40
Do	do	do	do	Woolen	1	......	8
Do	do	do	Warren	Cotton factory	1	16	150
Do	do	do	Taliaferro	Flour and grist	1	22	15
Tributaries of	Ogeechee	do	Liberty	do	1	[illegible]	20
Do	do	do	do	Saw	2	......	27
Do	do	do	Bulloch	Flour and grist	5	36	20
Do	do	do	do	Saw	[illegible]	17.5	24
Do	do	do	Screven	Flour and grist	1	10	8
Do	do	do	do	Saw	1	10	12
Do	do	do	Burke	Flour and grist	9	75 +	117
Do	do	do	Jefferson	do	9	82	189
Do	do	do	Washington	do	1	21	33
Do	do	do	Glascock	do	4	60	54
Do	do	do	do	Saw	2	23	27
Do	do	do	Hancock	Flour and grist	2	42	30
Do	do	do	Warren	do	1	9	12

XI.—THE ALTAMAHA RIVER AND TRIBUTARIES.

THE ALTAMAHA RIVER.

This river, with all its tributaries, lies entirely within the state of Georgia, and is the most southerly stream flowing into the Atlantic whose water-power is worthy of special mention. It is formed by the union of the Oconee and the Ocmulgee rivers, on the line between Montgomery and Appling counties, whence it pursues a south-easterly course, forming the boundary-line between Tattnall, Liberty, and McIntosh counties on its left, and Appling, Wayne, and Glynn on its right, emptying into the Atlantic ocean, through Altamaha sound, just below the town of Darien. Its length is about 75 miles in a straight line and 155 by the river, and its total drainage area comprises about 14,400 square miles, of which the Ocmulgee drains 6,000, the Oconee 5,400, and the Altamaha proper 3,000. Its principal tributary is the Great Ohoopee, from the north, draining about 1,400 square miles. The Altamaha is navigable for its entire length for boats drawing 5 feet of water, its fall being very slight. There are no important towns on the river. The mean rise and fall of the tides in Altamaha sound is 7 feet, and the tidal wave is felt for 30 miles or so above Darien.

The Oconee and the Ocmulgee rivers will be fully considered below. As regards the Altamaha, its drainage area lying entirely below the fall-line, it offers no power whatever, and the power on its tributaries is not worth mentioning. Some of them are sand-hill streams, but none offer large powers. Near the coast, and along the rivers, are extensive cypress swamps, and further inland there are large pine forests. Timber, turpentine, rice, cotton, fruits, and vegetables are the principal productions. The stream resembles the lower Savannah, the Santee, or the lower Pee Dee.

THE OCONEE RIVER.

I pass to the consideration of the Oconee and the Ocmulgee rivers, the only ones regarding whose water-power anything is to be said. The Oconee has its headwaters in Hall county, but the stream proper is formed by the union of its two forks, the North and the Middle, which unite just below the town of Athens, on the line between Clarke and Oconee counties, whence the stream pursues a course a little east of south for a distance of about 140 or 150 miles in a straight line, draining a total area of 5,400 square miles. It forms the boundary-line between Clarke, Oglethorpe, Greene, and Hancock counties on its left, and Oconee, Morgan, and Putnam counties on its right, flows through Baldwin, and between Wilkinson on its right and Washington and Johnson on its left, and finally through Laurens and Montgomery, to join the Ocmulgee. The only town of importance on the stream is Milledgeville, near which place it crosses the fall-line. The drainage area above this point being about 2,973 square miles, it will be seen that nearly half of the total area drained by the river offers no water-power of importance.

DRAINAGE BASIN
OF THE
ALTAMAHA RIVER.

There is a navigable depth of 5 feet up to the Central railroad bridge, 135 miles from the mouth of the strean In White's *Statistics of Georgia* it is stated that a boat 60 feet long once ascended to Barnett's shoals, 8 mile below Athens, but that no produce had ever been carried above Milledgeville. An examination of the river up t that town was made in 1874 under the direction of General Gillmore, whose report may be found in the *Annu Report of the Chief of Engineers*, 1875, Appendix U, and in which improvements by the general government we not recommended, as almost all the transport on the river is that of timber.

The accompanying map will show the form and dimensions of the drainage-basin of the Oconee, and of it principal tributaries. The rainfall on the basin above the fall-line averages about 48 or 49 inches—12 in spring, 1 in summer, 10 in autumn, and 14 in winter. The table on page 147 gives more detailed information on this subjec Some idea of the declivity of the stream may be obtained from the following table:

Table of declivity of the Oconee river.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall betwee points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet per mile*
Mouth of Altamaha	—155	0			
Crossing of Georgia Central railroad*	135±	201	290	201	0.
Crossing of Georgia railroad (Milledgeville)†	195±	221±	60	20	0.
Crossing of Georgia railroad (Augusta to Atlanta)†	255±	308	60±	87	1.
Crossing of North-Eastern railroad (2 miles north of Athens, north fork of Oconee)‡	295±	577	40±	269	6.
Second crossing North-Eastern railroad, 2 miles south of Lula‡	340	1,205	45	628	14.

* For this elevation, and others on the same road, I am indebted to Mr. William Rogers general superintendent.
† For these elevations I have to thank Major Wilkins, engineer of the road.
‡ These figures were furnished by Captain J. C. Turner, chief engineer of the road, at the request of the general superintendent, Mr. Lyman Wells.

The declivities given in the preceding table are of very small value because of the inaccuracy in the distance which could only be roughly estimated.

No gaugings of the Oconee are on record. The flow is said to be quite variable, and there seems to be no doul that it fluctuates to a greater extent than in the case of some streams which have been discussed on account the smaller rainfall in the warm season. The freshets are violent and very sudden. The sources of the rive being east of the mountains, and the soil clay or loam, the water is shed quite rapidly, and rises sometimes 8 10 feet in a few hours, overflowing its banks in many places, and flooding large areas of bottom-land. The ma will show how accessible the river is in its various parts.

A detailed description of the water-powers of the stream will now be given.

Below Milledgeville the stream is very tortuous, distances by river being usually reckoned at three times thos by land. The bed is generally of sand, the banks of clay, and the principal obstructions to navigation are snags an fallen trees. Near Milledgeville occurs the first fall, there being a series of shoals there extending over a distan of 5 or 6 miles, where the stream crosses the fall-line. A survey of these shoals was made several years ago by Colon B. W. Frobell, of Atlanta, who found the fall between the mouth of Fishing creek, which empties into the river fro the right just at Milledgeville, and the head of a shoal known as Carter's, to be 34.2 feet. The developme of this power by leading a canal from the head of Carter's shoals down to the city, rendering available a fall between 30 and 40 feet, has been often proposed, but nothing has yet been done toward carrying out this schem At present Carter's shoal is used for a cotton-gin, and formerly there used to be a grist- and saw-mill there; and jus opposite Milledgeville there is a grist-mill with a wooden wing-dam extending across to an island, and using a fa of 5 feet. The topography of the country between Carter's shoal and the city is said to be such that a canal woul be practicable, although there are bluffs in places. I have estimated the flow and power as follows:

Table of flow and power at Milledgeville.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*34 feet fall*
Minimum	2,973	34	500	56.8	1,9
Minimum low season			650	73.8	2,5
Maximum, with storage			2,600	295.5	10,0
Low season, dry years			740	84.1	2,8

Passing over one shoal, where there is said to be a fall of 3 or 4 feet, the next power is at Fraley's mill, 7 mile above Milledgeville, where there is an abrupt fall of 5 feet in 200, and about 8 feet in one-fourth of a mile, know

as Cedar shoal. A fall of 5 feet is used by a mill on the left bank, with a wing-dam, mostly of rough rock, extending about one-third across the stream. The available fall is probably 6 or 8 feet. The mill is stopped often on account of high water.

At Satcher's shoal, 15 miles above Milledgeville, and above the mouth of Little river, which enters from the west, there was formerly a grist-mill, not now in operation, but the fall is said to be only 4 or 5 feet. The river is narrow, with bluffs on each side, and the dam extends entirely across.

Graybill's old mill, not in use now, is said to have a fall of 4 or 5 feet.

Lawrence's grist-mill has a dam across to an island and no race. The dam is said to be 6 feet high, and the fall used 6 or 7 feet.

Riley's shoal is said to have a fall of 7 or 8 feet, but it is not improved.

One mile above is the site of the old Long shoal factory, or the mill of the Atwood Manufacturing Company, situated some 20 or 22 miles from Eatonton, which is the nearest railroad point. The fall is about 12 feet in one-fourth of a mile, as ascertained with a pocket-level, but it could probably be increased by a dam to 15 or 20 feet, as the banks are said to be quite steep for 2 miles above. The banks at the shoal are favorable for building. The old factory was located on the left bank, with a wing-dam extending for 500 yards or so up the river, the fall used being about 8 feet. This factory has not been used since the war, and at present the only power used is for a grist-mill on the right bank, with a dam only 50 feet long and 7 or 8 feet high, across to an island not subject to overflow, at the head of which is a little wing-dam to turn the water between the island and the shore. The location is safe on either side of the river, and considerable power could, no doubt, be developed at this place. The following table gives my estimate:

Table of flow and power at Long shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*34 feet fall.*
Minimum	2,122	12	360	40.9	490
Minimum low season			460	52.2	625
Maximum, with storage			1,860	211.3	2,535
Low season, dry years			530	60.0	720

Reid's mill-site, 6 or 7 miles above this shoal, is not now in use, the dam having been washed out fifteen or twenty years ago, and there being nothing there now. The dam extended entirely across, and a fall of 6 feet was used, but there was often difficulty with high water.

Passing a shoal where there is only a small fall, said to be 2 feet or so, capable of being increased to 5 feet, the next power is at Park's old mill, now used as a grist-mill, with four pair of stones, and a fall of 8 feet. The dam is of wood and stone, 350 feet by 8, ponding the water for 2 or 3 miles, with an average width of 300 feet, but without throwing the river out of its banks. The mill is troubled occasionally in times of high water, but there is never trouble from lack of water. It is 2 miles below the crossing of the Georgia railroad.

Just above the railroad the Oconee receives a large tributary, the Appalachee, from the west. Three miles above, at Willis' ferry, there is said to be a small shoal, but of no consequence, the next power worth mentioning being Scull shoal, 14 miles northwest of Greensborough, 8 miles from Maxey's, the nearest railroad point (on the Athens branch of the Georgia railroad), 12 miles from Madison, and about 15 miles above the railroad bridge. It is used by the cotton factory and grist-mill of the Powell Manufacturing Company. The dam is of wood and stone, 300 feet long and 10 feet high, and was built about the year 1860, having never been carried away. It ponds the water for about 2 miles, with an average width of 200 feet. From it a race 300 or 400 feet long leads to the factory, where the fall is 10 feet. The mill runs 3,200 spindles, and is never troubled with scarcity of water; but it is obliged to stop entirely during one or two months on account of backwater. No steam-power is used.

The next shoal, and the last of importance on this stream, is Barnett's or Veal's, 8 miles below Athens, and the finest shoal on the river. It is popularly supposed that the fall amounts to 60 feet within a distance of three-fourths of a mile. I visited the place, and, although unable to make any accurate observations, some rough measurements with a pocket-level rather inclined me to believe that this figure is too high, and that 45 or 50 feet would be nearer the truth. Not all of this fall, however, is easily available, on account of the character of the banks, which are steep on both sides on the lower half of the shoal. At the head a fall of 25 feet could be easily rendered available, with room for buildings on the left bank. The bed of the stream is rock, and at the head a natural dam extends entirely across, diagonally down stream from the left bank to the right, and, therefore, not just favorable for turning the water to the left bank. Over this ledge occurs the most rapid fall, amounting to 25 feet in about 300 yards. The rest of the fall would be very difficult to utilize fully by canaling, though it probably could in some way be developed if necessary. The river is about 180 feet wide above the shoal, and very deep, and the banks are low and sandy. In a heavy freshet the river rises here 6 or 7 feet, while three-fourths of a mile above it rises 17 feet, and on the shoal itself scarcely ever over 3 or 4 feet. This shoal is at present unutilized, although it has been

proposed to establish a cotton factory there. It is one of the finest sites in this part of the state. Fine buildi stone is found in the immediate vicinity, the climate is healthy, and it is said that a branch road could, with much difficulty, be run from the Georgia railroad. The following table will give an idea of the available power

Table of flow and power at Barnett's shoals.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second.	Horse-power available, gros		
	Sq. miles.		*Cubic feet.*	*1 foot fall.*	*25 feet fall.*	*45 feet.*
Minimum	860	......	137	15.6	390	
Minimum low season			180	20.5	510	
Maximum, with storage			900	102.3	2,560	
Low season, dry years			206	23.4	585	

* Twenty-five feet, easily available; total, 45 feet or more.

From what has been said, it will be seen that the Oconee does not offer a remarkable amount of power, but, the contrary, that it has few powers of much importance, and none to compare with the great powers on Catawba, Broad, and Yadkin rivers. The following table gives a summary of power, in which it has not b thought desirable, on account of uncertainty of the data, and the fact that the estimate is of no practical value insert estimates of the total theoretical power.

It may be mentioned that in January, 1827, the Oconee was frozen over near Milledgeville, and the Savan at Augusta—a circumstance never before known. In February, 1835, the thermometer fell to 3° below zero Eatonton, and to 8° below zero in Milledgeville.*

Summary of power on the Oconee river.

Place.	Distance from Milledgeville (or mouth).	Drainage area.	Rainfall. Spring.	Rainfall. Summer.	Rainfall. Autumn.	Rainfall. Winter.	Rainfall. Year.	Fall. Height.	Fall. Length.	Horse-power available, gross.* Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Utilized. Horse-power, net.	Utilized. Fall.	Per cent. of minimum utilized.	Remark
		Sq. ms.	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*							*Feet.*		
Milledgeville	0	2,950	12	13	9	14	48	34.0	5–6 miles	1,930	2,500	10,000	2,860	<50	6.0	<4	
Shoal	......	......	12	13	9	14	48	4.0	......	......	......	......	......	0	0.0	0	
Fraley's mill	7	2,900±	12	13	9	14	48	8.0	1,200 feet	450	580	2,320	660	<50	5.0	<17	
Satcher's shoal	15	......	12	13	9	14	48	5.0	......	......	......	......	......	0	0.0	0	
Graybill's mill	......	......	12	13	9	14	48	4.0	......	......	......	......	......	0	0.0	0	
Lawrence's mill	......	......	12	13	9	14	48	6.0	......	......	......	......	......	......	6–7	......	
Riley's shoal	46	......	12	13	9	14	48	7–8 (?)	......	......	......	......	......	0	0.0	0	
Long shoal	47	2,122	12	13	9	14	48	12+	1,300 feet	490	625	2,535	720	<50	0.0	<15	
Hill's shoal	......	......	12	13	9	14	48	Small	......	......	......	......	......	0	0.0	0	
Reid's shoal	54	......	12	13	9	14	48	6.0	......	......	......	......	......	0	0.0	0	
Park's mill	58	1,635	12	14	9	14	49	8.0	0	240	310	1,400	350	50	8.0	30±	Mill at d
Scull shoal	75	1,000	13	15	10	15	53	10.0	0	180	240	1,140	275	80±	10.0	60±	Dam 10 f
Barnett's shoal	90	860	13	15	10	15	53	45±	¾ mile	700	920	4,600	1,050	0	0.0	0	
LITTLE RIVER.																	
Gage's shoal	0.75	690	10	12	9	13	44	Small	......	......	......	......	......	0	0.0	0	
Moultrie's shoal	2.00	675±	10	12	9	13	44	Small	......	......	......	......	......	0	0.0	0	
Humber's mill	3.00	600±	10	12	9	13	44	9.0	0	......	......	......	......	25	9.0	......	
Pierson's mill	......	......	10	12	9	13	44	6–8	0	......	......	......	......	......	6–8.0	......	
Grist-mill	......	......	10	12	9	13	44	13.5	......	......	......	......	......	25	13.5	......	
Grist-mill	......	......	10	12	9	13	44	8.0	......	......	......	......	......	25	8.0	......	
Old factory	15.00	250	10	12	9	13	44	18.0	600 feet	......	......	......	......	0	0.0	0	

* See pages 18 to 21.

TRIBUTARIES OF THE OCONEE RIVER.

Below Milledgeville the tributaries are not of very much importance, except a few which may be classed as sa hill streams, but regarding which I could obtain no information, as none of them are utilized to any g extent. Power could no doubt be developed on many of them, and perhaps large powers on some of them, but

special sites could be specified. Of these tributaries Palmetto creek drains 375 square miles, Big Sandy creek 284, Commissioner's creek 196, and Buffalo creek 286. In the table of utilized power will be found a statement of the power used on these tributaries.

The first tributary worthy of special mention is Little river, which rises in Walton and Newton counties, flows southeast through Morgan and Putnam counties, passing within 3 miles of the town of Eatonton, and joining the Oconee between Putnam and Baldwin, about 8 or 10 miles above Milledgeville, and above Fraley's mill. Its length in a straight line is about 40 or 45 miles, but 60 or more by the course of the stream, and its drainage area is about 690 square miles. It has two tributaries worth naming, viz, Cedar and Murder creeks, both entering from the west. The stream is said to be "remarkable for its rapid current",* and it offers a number of good sites for small powers. Proceeding up the river, the first shoal met with is about three-fourths of a mile from the mouth, known as Gage's shoal, not improved, and with an unknown fall. A mile and a quarter further up is Moultrie's shoal, also unimproved. Both of these shoals are subject to backwater from the Oconee river, and their falls are stated to be small. They are probably not of much value for manufacturing. The next power is at Humber's mill, 3 miles from the mouth, with no important tributaries below it. The dam is of wood, 130 feet long and 9 feet high, and the fall used is 9 feet, with 28 horse-power, which can be obtained all the time. The fall could be increased to 11 feet, and the available power in the low season of ordinary years with this fall would probably be at least 100 horse-power. I would, by analogy, estimate it at a considerably larger figure, but as Colonel Humber, who is well acquainted with the stream, writes that 60 horse-power would be available with a fall of 11 feet, it must be that for some reason the flow of the stream is quite variable indeed, or else that the drainage area is much smaller than I measured it from the map. For this reason I do not venture to give estimates for the stream. The rainfall on the drainage-basin is, it is true, considerably smaller than on most streams thus far considered, being only about 44 inches, distributed unfavorably, too, for rendering the flow uniform, viz: spring, 10; summer, 12; autumn, 9; winter, 13 to 14; hence, without further data, I would have assumed the flow in the low season of ordinary years at about 0.18 cubic feet per second per square mile, or 108 cubic feet per second for 600 square miles, which would give a power of 12.3 horse-power per foot fall.

The next power above Humber's is at Pierson's mill, but the fall is only 6 or 8 feet, with a dam of the same height. Then follows a second mill, with a fall of 13½ feet and 25 horse-power utilized, and then a shoal, part of which was at one time used by the old Eatonton factory. This shoal, which is the first of importance on the river, is 3 miles from Eatonton, and about 15 miles from the mouth of the stream. The fall is about 25 feet in a distance of about 300 yards, over a bed of solid rock, with banks not subject to overflow, and offering good facilities for the construction of canals and buildings. At the lower end of this shoal there is a grist-mill, using a fall of 8 feet, with a wooden dam 200 feet long and 4 feet high, backing the water about 100 yards. This mill has four pair of stones, but two of them cannot be run in summer; the dam, however, is leaky, and the wheel very poor. At the head of the pond, on the right bank, the old factory was located, using a fall of 15 or 18 feet, with a race about 200 yards long, and a dam not over 4 or 5 feet in height at the head of the shoal. From measurements with a pocket-level, I think that 18 feet could easily be utilized. The bed of the stream at the head of the shoal is exceedingly favorable for the construction of a dam, but a high one could probably not be built without overflowing considerable good land. The factory was burned in 1864, since which time the power has not been utilized. The drainage area above is about 250 square miles, and I should think that a power of at least 75 horse-power could be utilized with 18 feet fall in the low season of ordinary years; but, as before mentioned, there may be circumstances rendering the flow of this stream very variable.

Above this site there are a few grist-mills on the stream which it is not necessary to specify. On some of the tributaries to the stream there are also mills, and on Murder creek, about 3 miles from its mouth, it is said that a fall of 18 feet could be utilized with a dam 6 feet high and a race 200 yards long.

The next tributary worth naming is the Appalachee river, which has its sources in Gwinnett county, whence it flows southeast, and joins the Oconee just above the railroad bridge. Its length in a straight line is about 54 miles; by the river, 80 miles or over. It drains an area of about 506 square miles, receiving as its principal tributary Hardlabor creek, from the west, which drains about 173 square miles. Data regarding its flow or fall could not be obtained. The rainfall on the basin is about 47 inches—11 in spring, 13 in summer, 9 in autumn, and 14 in winter. The stream is quite inaccessible, as the map will show. The following are the powers in their order as the river is ascended:

About a mile and a half above the railroad there is said to be a small shoal, not used, and probably of no value. Four miles further up is Reid's mill, not now used, the available fall being stated at 7 or 8 feet, and perhaps more. The mill was burned during the war, but the greater part of the dam, which was of rock, and 4 or 5 feet high, is still there, though out of repair. This site is 4 miles below the mouth of Hardlabor creek, and 2 miles from Buckhead, the nearest railroad depot. It is owned by Mr. W. H. McWhorter. Estimates of the flow are liable to considerable uncertainty, as remarked in the case of Little river, but I would estimate the flow and power at this place as in the table on page 149.

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* WHITE: Statistics of Georgia, 1849.

Flow and power at Reid's mill, Appalachee river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power av able, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*8 feet j*
Minimum	500	8	60	6.8	
Minimum low season			66	7.5	
Maximum, with storage			525	60.0	
Low season, dry years			76	8.6	

Ten miles up the river, and above the mouth of Hardlabor creek, is Furlow's grist-mill, where a fall of 8 f and 30 horse-power are used. The dam is of wood, 300 feet long, 5 feet high, and backs the water 300 yards. T head-race is 150 feet long. The drainage area above is about 310 square miles, and I would therefore estimate power as follows:

Flow and power at Furlow's mill and shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second	Horse-power available, gross.			Remarks.
	Sq. miles.		*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	*18 feet fall.*	
Minimum	310	....	37	4.2	34	76	Fall of shoal fron formation from Furlow.
Minimum low season			41	4.7	38	85	
Maximum, with storage			325	37.0	296	666	
Low season, dry years			47	5.4	43	97	

* Eight feet at mill; 18 feet at shoal above mill.

The shoal referred to in the above table is one-quarter of a mile above the mill, and is a better site than one where the mill is located. The fall is said to be about 14 feet in 250 yards, and a dam 4 feet high co probably be built, giving a total available fall of 18 feet. The bed is rock, and the banks steep and rocky at upper end of the shoal. It is to be remarked that the Appalachee exhibits the same phenomenon—of filling with sand—that has already been referred to at length in the case of the tributaries of the Broad river in So Carolina. At Furlow's mill the fall was formerly 12 feet, but is now reduced to 8. The shoal just referred to l never been used. It is owned by C. M. Furlow, of Madison.

The next power is 5 or 6 miles above, at Price's mill, a grist- and saw-mill, using a fall of 16 feet and 25 hor power, the dam being 4½ feet high, and the race 225 feet long. The owner states that by carrying the race 100 f farther down the stream a fall of 20 feet would be obtained, and by going farther still even more could be used, shoal being half a mile long. This shoal is, no doubt, a fine one, and in the table below I have estimated the pov as nearly as possible:

Table of power at Price's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power availa gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*16 feet*
Minimum	300+	16	36	4.1	
Minimum low season			40	4.5	
Maximum, with storage			315	36.0	
Low season, dry years			46	5.2	

The next power is 4 miles above Price's, at High shoals, situated 14 miles from Athens and 16 from Madis The stream is said to fall about 55 feet in 300 or 400 yards, but the principal part of the fall occurs in the lov half of this distance. The fall is utilized by the cotton factory of the New High Shoals Manufacturing Compa and by a grist-mill and a cotton-gin. The bed of the stream is solid rock, the banks high and difficult to car and the width of the stream 200 to 400 feet. The cotton-factory dam is located about the middle of the shoal, a is of wood, straight across the stream, 400 feet long and 5 or 6 feet high, built in 1873 at a cost of $500, and back the water only one or two hundred yards. The race is 200 feet long, the fall 20 feet, and the power 100 hor power, which can be secured during 11½ months as a rule, and 75 horse-power for the remaining time, there be no waste in summer while running.* Just above the pond is a fall of 4 or 5 feet, used for running a gin, while j below the factory is a grist-mill with no dam, a wooden flume about 120 feet long and a fall of 20 feet runnin pair of stones. Below this mill there is a fall, not used, of 6 or 8 feet.

The drainage area above this shoal is about 300 square miles. I have based my estimates of power for river principally on the above data regarding the factory as furnished by Dr. Powell, the president of the compa Although not of so much interest here, I subjoin a table. Taking 75 horse-power net as the power, with a fall of

feet during the low season of dry years, or assuming the efficiency of the motor to be 75 per cent. and the gross power 100 horse-power, the power per foot fall is 5 horse-power. On this the following estimates are based:

Table of power at High shoals.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	*55 feet fall.*
Minimum	300	55 ±	36	4.1	80	225
Minimum low season			40	4.5	90	250
Maximum, with storage			315	36.0	720	1,980
Low season, dry years			46	5.2	100	228

Above this shoal comes a site not utilized, said to have a fall of 15 or 20 feet; but no information could be obtained regarding it.

Five miles above High shoals is Snow's grist-mill, with a fall of 10 or 12 feet and a dam of about the same height; and further up the stream are other small grist-mills, but they are not worthy of special mention.

The Appalachee has one tributary worth naming, viz, Hardlabor creek, from the west, which drains 173 square miles. It is, however, not a good stream for water-power, and has only one site worth mentioning, about 3 miles from its mouth, and just above where Sandy creek joins it. This site was formerly used, and the available fall is stated at 10 feet; but the power is small, and the fall subject to being diminished by backwater from the Appalachee. The stream is sluggish and without power above this. Sandy creek, a tributary of Hardlabor creek, drains about 72 square miles, and is said to have a shoal about 2 miles long, on which there were formerly 4 mills, but now only 1 remains. This shoal is about 8 miles from Madison.

The Oconee river is formed by the union of the North and Middle forks a few miles below the town of Athens. It remains to describe these two streams. The North fork rises in Hall county, and flows through Jackson and Clarke counties, its length in a straight line being about 43 miles, and its drainage area 433 square miles. It flows directly by the town of Athens, the most important place in the vicinity. The table of declivity on page 145 will show that the stream has quite a rapid fall. There are, however, few mills on it, and few sites were brought to my notice. It is probable that the greater part of the fall occurs in the upper parts, before the stream is large enough to be of much value for power.

The first shoal is sometimes known as Smith's, and is less than a mile above the junction of the two forks; but according to all accounts the fall is small and the power not valuable.

The next power is at the factory of the Georgia Manufacturing Company, where the fall is 20 feet in a distance of one and a half miles or thereabout. The dam is of wood and stone, but built in a rather peculiar way. A stone dam of triangular or trapezoidal section is first carried entirely across the stream, and on top a wooden sill is laid; while at the bottom and on the up-stream side a second sill (mud-sill) is also laid, both extending from bank to bank. On these two sills the planking is laid, sloping thus upward and down stream and projecting down stream beyond the almost vertical face of the stone dam. This dam of the Georgia factory is 300 feet long and 10 feet high, and was built in 1840. The foundation is solid rock, and the pond is about a mile long and 150 feet wide. A race, 600 yards long, leads to the factory, where the fall is 20 feet, using 150 horse-power, which can be obtained at all times, but with no waste during working hours in the dry season. These data give a net capacity of 7½ horse-power per foot, or, say, 10 horse-power gross per foot, during the low season of ordinary, or, perhaps, dry years, corresponding to 0.20 cubic feet per second per square mile of drainage area. I have taken this as referring to dry years, because it is to be expected that the flow of this stream is more regular than that of the other tributaries of the Oconee thus far considered, since the rainfall is both larger and more favorably distributed, being as follows: spring, 15; summer, 15; autumn, 10; winter, 16; year, 56. The following table, therefore, gives my estimate of flow and power here:

Table of power at Georgia factory, on the North Oconee river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*
Minimum	433	20	70	8.0	160
Minimum low season			85	9.7	194
Maximum, with storage			475	54.0	1,080
Low season, dry years			100	11.4	228

This factory is a mile above the junction of the two forks.

Above this power comes a small shoal, where it is said that a fall of 6 feet could be obtained, known as the Lumpkin shoal, but it is probably not of much consequence.

The next important power is the Athens cotton factory, at Athens, about 4 or 5 miles above the junction of the two forks. The dam is constructed like that at the Georgia factory, and is 300 feet long and 10 feet high. It was built in 1847, and would perhaps cost $5,000. The foundation is solid rock. The race is only a few feet in length and the fall 12 feet, and 180 horse-power is used. Opposite the factory, on the east bank, is a grist-mill, with a race about 330 feet long and a fall of 13 feet, with 60 horse-power. The total power used is therefore 240 horse-power; but this cannot be obtained all the time, and the grist-mill is sometimes stopped in dry weather to allow the factory to use all the power. Still, I was informed that the factory could not be run at full capacity more than about 10 months of the year, the power during the rest of the time being considerably less, even by drawing down the water at night in the pond (which is 3 miles long and 100 to 150 feet wide) to a certain extent, the factory being run 11 hours a day. These data give the power in the low season at somewhere in the neighborhood of 8 or 10 horse-power per foot fall gross, and as the data from the Georgia factory are the more reliable, on account of the fact that in this case it is impossible to say to what extent the water is drawn down in the pond, I take the figures used in the previous table, which give for 12 feet fall powers of, respectively, 96, 116, 650, and 137 horse-power for the natural flow of the stream, and in ordinary years, of course, about 170 horse-power. The dam of this factory was partially washed away by a freshet in the spring of 1881.

There is no power on the stream for 12 or 13 miles above the Athens factory, the next power being at Burn's mill, now Hood's mill, where the fall is 10 feet, with a dam 9 feet high, the power not being of much importance.

The next shoal is Hurricane shoal, in Jackson county, 16 or 17 miles above Athens, where the fall is 26 feet* in a short distance, and the location is said to be safe. The power, if used at all, is only used to run a small grist-mill, with a few pair of stones. As nearly as I could locate the place, the drainage area above it is about 230 square miles, the rainfall being the same as already given. I would therefore estimate the power about as follows:

Table of power at Hurricane shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*26 feet fall.*
Minimum	230	26	36	4.1	107
Minimum low season			45	5.1	133
Maximum, with storage			257	29.2	759
Low season, dry years			52	5.9	153

This site is conveniently located about 3 miles from the North-Eastern railroad, and is said to be a very good power.

Above this there are other shoals, some of them utilized to run small grist-mills; but regarding them I have no data, and as the stream is small it is needless to specify them. This part of the state has a healthy and salubrious climate, and offers many inducements to manufacturers. Its water-powers will doubtless be developed before long.

The Middle Oconee, or Middle fork, takes its rise in Hall county, and, like the North fork, flows through Jackson and Clarke counties, to join the latter stream. Its length in a straight line is about 40 miles, and it drains a total area of 407 square miles, receiving as its principal tributaries Mulberry fork, draining 97 square miles, and Barber's creek, draining 74 square miles. The fall of the stream I am unable to state, but it probably does not differ much from that of the North fork, which it resembles in all respects. If anything, the latter is more rapid, the Middle Oconee being said to have many low, flat, and rich bottom-lands along its banks, and to be rather sluggish in many places.

The first shoal on the stream is known as the Simalton shoal, and is a mile or so from the mouth, but the fall is small, and of no value for manufacturing.

The next is the Princeton factory (cotton), 2 miles from the mouth and 3 miles from Athens, which is the nearest railroad point. The dam is similar to those already described on the North fork, and is 320 feet long, 9 feet high, and was rebuilt in 1880 at a cost of about $5,000, having been constructed originally about 40 years ago. The foundation and abutments are of rock, and the pond is 2 miles long, with an average width of 150 feet. The length of the head-race is 300 yards, and it is 20 feet wide and 2 to 3 feet deep. The fall at the factory is 20 feet, and 100 horse-power is used, and can be obtained all the time, with a waste of water at all seasons. The wheels are stopped by high water several days in the year, and sometimes two weeks or more in all. The freshets on the stream are quite severe, and in 1880 there were several very large ones—the largest since the "Harrison freshet" of May, 1840. In April, 1880, the water rose 27 feet at the factory, and was 7 feet over the dam, overflowing the canal, and causing a stoppage of work for six days. In 1879 the head-gates and canal banks were washed out during a freshet, and the factory was stopped for one month. I have estimated the power at this site as in the table on page 152.

*JANES: Handbook of Georgia.

Table of power at Princeton factory.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		Remarks.
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	
Minimum	330	20	52	6.0	120	Low season of ordinary years, 215 horse-power.
Minimum low season			66	7.5	150	
Maximum, with storage			363	41.2	825	
Low season, dry years			77	8.7	175	

The next power is Jennings' grist-mill, 3 miles above, where the fall is 8½ feet, with a dam 4 feet high. The power utilized is very small. That available may be calculated by comparing with the above table for the factory, the quantity of water being about the same at both places.

McElroy's mill is the next power, 1½ miles above, and 4 miles from Athens. The fall is 13 feet, with a dam 6 feet high and a race 300 feet long. The mill runs 3 pair of stones, and can be run all the year. The power available can be approximated to as above, there being no tributaries of importance between this place and the factory.

The next power is at Tallassee falls, 8 or 9 miles from Athens, and about 4 miles above McElroy's mill. This shoal is 1,200 yards long, and the total fall is stated to be 51 feet.* Part of this fall was at one time used by a cotton factory, but now only by a grist-mill, located at about the center of the shoal, with a wing-dam, a race 300 yards long, and a fall of 14 feet. The whole fall of the shoal could without difficulty be utilized, but in two parts—the upper part being used on the left bank, and the lower on the right. There was formerly a saw-mill on the right bank near the foot of the shoal. The bed of the stream is rock, gravel, and bowlders, and its width is from 150 to 200 feet. The following table shows my estimate of the power:

Table of flow and power at Tallassee falls.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*51 feet fall.*
Minimum	307	51	50	5.7	290
Minimum low season			61	7.0	360
Maximum, with storage			340	38.6	1,970
Low season, dry years			70	8.0	410

Above this shoal there are said to be no large powers on the stream, although there are some sites where grist-mills might be located, and some mills in operation.

Of the tributaries to the Middle Oconee, the first is Barber's creek, which enters below the Princeton factory from the west, draining 74 square miles.

Half a mile from its mouth is the Pioneer paper-mill, using a fall of 20 feet and 120 horse-power, which can be obtained during nine months, while for the rest of the year only 60 horse-power can be obtained. Steam-power to the extent of 30 horse-power is used all the time, and 80 horse-power during three months. Three miles from the mouth is an unutilized power known as Epps' shoal, the fall being stated at 24 feet in 60 yards, all available. Four miles above is a third site, not used at present, the fall being stated at 20 feet in 300 yards.

Mulberry fork, which enters the Middle Oconee above Tallassee falls, drains 97 square miles, and has some shoals, used and idle, on the main stream and tributaries, many of which might doubtless be utilized with advantage, affording good powers, though small.

THE OCMULGEE RIVER.

This stream has its sources in Fulton, De Kalb, and Gwinnett counties, but the stream proper is formed by the union of the South and the Yellow rivers between Butts and Newton counties, whence it flows in a general direction rather east of south to join the Oconee, passing by the city of Macon, the town of Hawkinsville, and a few other small towns. It crosses the fall-line at Macon, which is the head of navigation, and below which there is no power. At present the stream is navigable as far as Hawkinsville, 200 miles, for boats drawing 5 feet. Regarding the length of the river I have no data, but the distance from Macon to the sea is generally called about 500 miles.† It drains a total area of 6,000 square miles, of which about 2,250 are above Macon, so that the water-power district is not quite so large as in the case of the Oconee. The character of the stream, of its flow, of the drainage-basin, and

* By Mr. J. W. Bromby, of Athens, who measured it.

† *Annual Report Chief of Engineers*, 1872, p. 516.

of the rainfall, is about the same as in the case of the Oconee. The declivity is probably also about the same, though I have few data regarding it. The elevation of the river at Macon is probably about 275 feet, and, according to the report on the canal route to connect the Ocmulgee and Tennessee (*Annual Report Chief of Engineers*, 1872, p. 531), it seems that the fall between this point and the head of the river is 270 feet, but I am not able to state with any accuracy the distance between the two places.

I proceed to describe the river as a source of water-power more in detail.

The first power is near Macon, where the stream crosses the fall-line, and where, like the Oconee and the Savannah, it forms a long shoal, several miles in length. It has at various times been proposed to construct a canal from a point on the river 10 miles above the city down to a small stream called Vineville branch, which enters the Ocmulgee half a mile above the city limits, and to utilize the water-power for manufacturing, at the same time supplying the city with water; and it is said that the available fall at Vineville branch would be 42 feet or thereabout. The project was started in 1871, and the Macon Canal and Manufacturing Company was organized; but as yet nothing has been done. It is said, on good authority, that the scheme is perfectly practicable, but opinions differ as to the difficulties involved. The difficulty in bringing the canal down to the city lies in the fact that between the latter and Vineville branch is a ridge which would be difficult to cut through, and a cemetery which could probably not be crossed. It is asserted by some that the canal could be built for $250,000, and that little blasting would be required,* the length of the canal being 9½ miles. It was proposed to build a dam 5 feet in height at its head, where the bed of the stream is solid rock, there being a very favorable site for its location. Along the line of the canal there are said to be fine clay deposits, and near its head an abundance of very fine granite. The shoals on the river below the proposed head of the canal are known as Healy's, Wicked, Wimbush's, and Cemetery. At the former, which is 7 miles above Macon in a straight line, it is said that there is a fall of nearly 10 feet in 300 yards; and at Wicked shoals it is said that the fall is 8 feet in a mile, while the Cemetery shoal, which is below the mouth of Vineville branch, has only a small fall.

The project of utilizing this power is not now spoken of much, and I was unable to see the original reports and estimates, which have been lost. The only report that I could find is one by F. P. Holcomb, engineer, published some years ago in one of the Macon daily papers. It is there stated that the fall from the head of Healy's shoals to Macon, a distance of 7.6 miles by the canal, is 31 feet; adding 7 feet for a dam, and subtracting 4 feet for friction, the available fall is 34 feet. By going further up stream with the canal, this may be increased to 40 feet or thereabout.

The drainage area above Macon is about 2,250 square miles, and I have estimated the power in the table below. The flow of the stream is said to be quite variable, indeed—a characteristic we have noticed in the case of the Oconee. The freshets are very heavy, and the stream rises sometimes 22 feet at Macon. There have been no continued gaugings of the river, but it is stated that the flow at average low water is about 1,100 cubic feet per second. The fact that in Holcomb's report, above referred to, the ordinary low-water flow is given at 481 cubic feet per second will show the unreliability of a single measurement. It is said that in 1839 the flow was at its minimum, and was 360 cubic feet per second.

Table of power at Macon canal (projected).

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*40 feet fall.*
Minimum	2,250	40±	360	41.0	1,640
Minimum low season			475	54.0	2,160
Maximum, with storage			2,150	244.3	9,770
Low season, dry years			540	61.3	2,450

It is to be remarked here that the above estimates have been made entirely independent of the measurements referred to above, and the agreement is surprising. The minimum is found by taking the discharge at 0.16 cubic foot per second per square mile, the same figure that was assumed for the Oconee above Milledgeville, and arrived at by a careful consideration of all the circumstances.

The economical location of Macon is very favorable, and the map will show that a number of railroads diverge from the city. The Ocmulgee is navigable (or can be made so) up to the place for boats carrying 1,000 bales of cotton. The navigation is unobstructed as far as Brunswick, but above that point it is obstructed by two bridges.

The river has been examined above Macon by Colonel B. W. Frobel, under the direction of Major King, of the United States engineer corps, and his report is to be found in the *Annual Report of the Chief of Engineers*, 1876, Appendix P, p. 20. From this report most of the following information has been condensed. All the shoals specified in the report will be found mentioned in the table on page 154; but regarding many of them I have no information in addition to what is there given.

Holt's shoal, in the upper part of Bibb county, is not utilized. The stream is about 325 feet wide.

* BUTLER: Historical Record of Macon and Central Georgia, p. 292.

At Johnston's shoal the river is divided by three small islands, and the total width of the stream above the shoal is 450 feet, and below it 350. Harris' shoal is in Monroe and Jones counties, as are all the following shoals up to Head's shoal, which is just at the upper corner of Jones. The most important in this distance is Glover's Mill shoal, or Long shoal, which is used on both sides of the river, and is 4 or 5 miles below the upper corner of Monroe county, and about 10 miles from Forsyth. It is said that the entire fall is available, with good facilities for canals and buildings. The next shoal is Seven Islands shoal, in Butts and Jasper counties, and about 20 or 25 miles from Forsyth. There was at one time a cotton factory at this place, but now there is only a grist- and saw-mill. The width of the stream at the head of the shoal is 350 feet, but it rapidly expands, and is 500 feet wide near the foot. It is said that the entire fall is available, and the site is called one of the best on the river. Roach's shoal is the next one which is utilized, there being a grist-mill on the left bank, with a canal nearly the whole length of the shoal, and a dam across a narrow arm of the river over to an island. The width of the stream at the head of the shoal is about 400 feet. The most important shoal above Macon, however, is Lloyd's, the total fall being over 39 feet in less than 2 miles, the principal part of which occurs at the head, in a distance of 2,000 feet, but the whole of which is probably available. The bottom is solid rock, and the banks generally high, except that on the left bank there is a bottom near the foot of the shoal. At Cap's shoal the river is divided by islands into three channels, the width just above the shoal being 350 feet. Just above Harvey's shoal the Alcovee river enters from the north. At Lemon shoal, the next one above, a natural rock dam extends almost entirely across the river, leaving an opening of about 50 feet, called Bull sluice. The last shoal on the river, Barnes', is just at the junction of the South and the Yellow rivers, and is utilized for a grist-mill. The head of the shoal is on both streams, and just at the junction of the two is a rock ledge, crossing both, and forming an almost perfect dam, with deep water above it. The width of the South river is about 325 feet; that of the Yellow river about 275 feet; and that of the Ocmulgee about 500 feet.

Not having visited any of the shoals on the river, I am unable to give detailed information regarding the practicability of utilizing them. It is evident, however, that the stream presents a large amount of theoretically available power and several fine sites almost entirely unimproved. Estimates of the power are in the following table.

The chief difficulty in the way of the utilization to a large extent of the water-power of the Ocmulgee is the inaccessibility of the stream. A new railroad, however, is now in course of construction from Macon to Atlanta, which will, I believe, follow the river quite closely, and thus remove this difficulty.

Summary of power on the Ocmulgee river.

Locality.	Distance from Macon.	Drainage area.	Rainfall.					Fall.		Horse-power available, gross.*				Utilized.		Per cent. of minimum utilized.	Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Maximum, with storage.	Low season, dry years.	Horse-power, net.	Fall.		
	Miles.	*Sq. miles.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*							*Feet.*		
Macon canal, projected	0	2,250	11	13	9	14	47	40±	10 miles	1,640	2,160	9,770	2,450	0	0	0	
Bibb county:																	
Holt's shoal		2,235	11	13	9	14	47	3.714	400 feet	150	200	900	230	0	0	0	Width, 325 feet.
Holman's shoal		2,200+	11	13	9	14	47	1.294	1,400 feet					0	0	0	Width, 400 feet.
Monroe and Jones counties:																	
Johnston's shoal		2,200+	11	13	9	14	47	5.125	1,500 feet	200	270	1,200	310	0	0	0	
Harris' shoal		2,200+	11	13	9	14	47	2.312	3,000 feet					0	0	0	Width, 350–400 feet.
Bowman's shoal		2,200+	11	13	9	14	47							0	0	0	
Taylor's shoal		2,200	11	13	9	14	47	5.732	2,100 feet	230	300	1,360	350	0	0	0	Width, 500 feet.
Rum Creek shoal		2,000+	11	13	9	14	47	Small						0	0	0	
Dame's shoal		2,000	11	13	9	14	47	3.644	400 feet	130	175	790	200	0	0	0	Width, 400–600 feet.
Falling Creek shoal		2,000−	11	13	9	14	47	1.566	3,200 feet					0	0	0	Width, 400 feet.
Clark's shoal		2,000−	11	13	9	14	47	Small						0	0	0	
Jarrell's shoal		2,000−	11	13	9	14	47	...do						0	0	0	
Mitchell's shoal		2,000−	11	13	9	14	47	...do						0	0	0	
Glover's Mill shoal		1,974	11	13	9	14	47	17.916	1,600 feet	650	850	3,870	980	50±	12±	11±	Width, 400 feet.
Head's shoal		1,640	11	13	9	14	47							0	0	0	
Butts and Jasper counties:																	
Island shoal		1,600±	11	13	9	14	47							0	0	0	
Seven Islands shoal		1,512	11	13	9	14	47	19.515	1,600 feet	530	700	3,350	800	<50	20?	13±	
Lamar's shoal		1,500±	11	13	9	14	47	3.953	1,300 feet	110	140	680	160	0	0	0	Width, 500 feet.
Roach's shoal		1,450±	11	13	9	14	47	7.500	3,900 feet	200	260	1,240	300				
Pitman's shoal		1,450±	11	13	9	14	47	3.510	1,800 feet	90	120	580	140	0	0	0	Width, 400 feet.
Lloyd's shoal		1,350±	11	13	9	14	47	39.627	9,500 feet	975	1,280	6,100	1,460				Width, 300–450 feet.
Cap's shoal		1,350±	11	13	9	14	47	5.580	400 feet	140	180	860	210	0	0	0	
Leverett's shoal		1,350±	11	13	9	14	47							0	0	0	
Harvey's shoal		1,340	11	13	9	14	47	4.000	600 feet	100	130	620	150				
Lemon's shoal		1,020	11	13	9	14	47	2.500	700 feet	50	70	325	80	0	0	0	
Barnes' shoal		1,017	11	13	9	14	47	11.645	500 feet	210	280	1,350	325				

*See pages 18 to 21.

TRIBUTARIES OF THE OCMULGEE RIVER.

Some of the tributaries below Macon are sand-hill streams, but none have large powers utilized, although such might perhaps be developed in places. On Mossy creek, a small stream flowing into Indian creek, which joins the Ocmulgee about 10 miles above Hawkinsville and drains a total area of 300 square miles, there is a cotton factory, with a fall of 12 feet and 60 horse-power, the dam being 10 feet high and the race 50 feet long.* This stream is said to be quite constant in flow, and drains about 116 square miles; and it seems probable that more power could be obtained on it. If its flow and its general character resembles that of the other sand-hill streams which we have considered, it would afford considerable power. I have no information of the streams below this. The largest tributary is probably the Little Ocmulgee, which drains a total area of 776 square miles, but it is so far below the fall-line that it is not probable that it affords much power.

Echaconnee creek, which joins the Ocmulgee from the west about 15 miles below Macon, is a considerable stream, draining 272 square miles. Its power, however, was not spoken of as remarkable, and it is utilized only by small grist- and saw-mills. It is probable that it partakes to some extent of the character of a sand-hill stream, and that its flow does not vary so much as that of the streams above the fall-line; but as I was not able to learn much regarding the stream I submit no estimates.

Tobesoffkee creek is a stream similar to the one last mentioned, rising in Monroe county, and flowing through Monroe and Bibb into the Ocmulgee, about 10 miles below Macon. It has a few small grist-mills, but no large powers were heard of. Its drainage area is 260 square miles.

The next tributary worth naming is the Towaliga river, which takes its rise in the western part of Henry county, and flows southeast, forming the boundary-line between Henry and Spalding, and then flowing through Butts and Monroe, joining the Ocmulgee just opposite the upper corner of Jones, after draining a total area of about 320 square miles as nearly as I could measure it, its length being about 33 miles in a straight line. Its total length is stated at 70 miles.† It is said to be quite a rapid stream, with not much bottom-land, except in its lower part. It has the following shoals:

Willis' shoal, 3 miles from the mouth, not used, though formerly there was a grist-mill there. The available fall is stated at 10 feet, with a dam.

High falls, about 15 miles from the mouth of the stream, 7 miles from Indian spring, 9 miles from Milner, the nearest railroad point, and 14 miles from Forsyth, is the best water-power on the stream or in the vicinity. The stream falls here 81½ feet in a distance of between 300 and 400 yards, but of this fall 49 feet is in one perpendicular pitch.‡ The power is used as follows:

At the head of the shoal is a wooden dam, 400 feet by 10, straight across the stream, with a race on each bank, one leading to a grist-mill, and the other to a saw-mill, the fall used being 13 feet. About 500 feet below the first dam is a second one, 200 feet by 3, its crest being 10 feet higher than the top of the high fall, 300 feet below. From this dam there is a race on each side, one leading to a cotton-gin, and the other to a gin and a wool-carding machine. The high fall is 49 feet perpendicular, and 200 feet below it is another shoal with about 10 feet fall, not used, followed for some distance by smaller shoals. The bed of the stream is solid rock, and the banks such that the entire fall of 71 or 72 feet is available. The drainage area above this place was measured and found to be about 200 square miles. I have therefore estimated the power as in the table below. Mr. Boardman states the flow at extreme low water at 162 cubic feet per second, but if my measurement of the drainage area is correct within a reasonable amount the flow must either be very much smaller than this or there must be some very exceptional features in the drainage-basin. The table below is estimated on analogy, and such features, if they exist, would modify the figures given. I have used nearly the same proportions in calculating this table that I used in the case of the Appalachee river.

Table of power at High falls, Towaliga river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*49 feet fall.*	*71 feet fall.*
Minimum	200	....	26	3.0	147	213
Minimum low season			31	3.5	172	248
Maximum, with storage			211	24.0	1,176	1,704
Low season, dry years			35	4.0	196	284

* Total, 82 feet; perpendicular, 49 feet; total in shoal proper, 71 feet.

The rainfall on the basin of the Towaliga is about as follows: spring, 10; summer, 12; autumn, 10; winter, 14. The site above described is worthy the attention of those seeking a location.

* Power stated in statistics of cotton-mills at 120 horse-power.

† WHITE: Statistics of Georgia.

‡ All of my information regarding this power is due to Mr. Arthur Boardman, of Macon, who has surveyed the power.

Flat shoal, 4½ miles above High shoal, is about 250 yards long, and the fall is said to be 10 or 12 feet. It is not improved, but is probably available. One mile above it is a second shoal, with a small fall, and 1 or 2 miles further up is another, but neither are probably of value. A short distance above, and about 10½ miles east of Griffin, in Spalding county, is Heflin's shoal, about half a mile in length, with a rock bottom, and banks 8 or 10 feet high, the fall being stated at 12 to 15 feet, with a dam 4 feet high; and it is said that a much higher dam could be constructed. Above are several small powers, but they are not worthy of special mention.

Little Towaliga creek, which drains about 55 square miles, and enters the main stream a few miles below High shoal, has 2 mills using a small amount of power, one of them with a fall of 27 feet.

The next tributary of the Ocmulgee worthy of mention is the Alcovee river, which enters from the left only about a mile below the junction of the South and the Yellow rivers. It takes its rise in Gwinnett county, pursues a course nearly south through Walton and Newton counties, entering the Ocmulgee on the line between Newton and Jasper, its length in a straight line being about 45 miles, and its drainage area about 320 square miles. In its upper part it is not favorable for power, being flat, and with no falls; and it is only below the Georgia railroad that there is any power worth mentioning. Its elevation at the crossing of the Georgia railroad is about 550 feet. The following are the powers on the stream as it is ascended:

Newton Factory shoal, or High shoal, about 5 or 6 miles from the mouth, and 11 or 12 miles from Covington, the nearest railroad point, is about half a mile in length, and the fall was variously stated at from 50 to 70 feet, the former of which I believe to be the more nearly correct, though I did not visit the place. At the upper part of the shoal is the Newton factory (W. R. Phillips, Atlanta), but the dam was washed out in the freshet of May, 1881. It was 200 feet by 6, affording a fall of 12 feet at the cotton-, saw-, and grist-mills, with a race of 25 feet. The lower part of the fall is used by the cotton factory of H. & T. M. White, with a dam of loose rock 50 or 60 feet long and 3 or 4 feet high, reaching only part way across the stream. A head-race of 60 feet gives a fall of 6 feet, and the power used is 20 horse-power. Above the factory is a grist-mill, with a small power. The total fall at this place is said to be available, and it is no doubt a fine power. The rainfall on all the drainage-basins of the Alcovee, South, and Yellow rivers may be given here once for all. It is: spring, 12; summer, 13; autumn, 10; winter, 13; year, 48. I have therefore estimated the power at the shoal above described as in the following table:

Table of power at Newton factory or High shoal, on the Alcovee river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second.	Horse-power available, gross.	
	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	50 feet fall.
Minimum	266±	....	37	4.2	210
Minimum low season			48	5.4	275
Maximum, with storage			264	30.0	1,500
Low season, dry years			55	6.2	315

* Probably 50 feet or over.

The next shoal is at Henderson's mill, 6 miles south of Covington, where the fall is 9 feet, with a dam 5 feet high and 180 feet long, which backs the water 4 miles. Above this the stream is sluggish, and there is said to be only one shoal, known as Hinton's, with a fall of 5 feet over a ledge of rock.

The principal tributary of Alcovee river is Bear creek, which enters from the left below High shoal, draining about 31 square miles.

The Yellow river, one of the two streams which form the Ocmulgee, takes its rise in Gwinnett county, and pursues a course a little east of south, cutting off a corner of DeKalb, and passing through Rockdale and Newton counties, draining a total area of about 422 square miles, its length being about 45 miles in a straight line. It passes within 3 miles of the towns of Conyers and Covington. It is a better stream for water-power than the Alcovee, and is said to be a bolder stream, with more rapid fall and less low ground. It is "very tortuous, presenting many abrupt turns, with high, sharp spurs jutting in and frequent rock cliffs, particularly for from 10 to 15 miles in the vicinity of Stone mountain".* The finest quality of granite is found in this vicinity in inexhaustible quantities.

The shoals will now be described in their order:

The first is Indian Fishery shoal, where the fall is 12.2 feet in 400. At the head of the shoal a natural rock-dam extends entirely across the river, with deep water above it. A fall of 11 feet is used by a grist-mill on the right bank, which is the most favorable side for building, the left bank being steep. The width of the stream is about 320 feet. The table on page 157 gives estimates of the power.

* *Annual Report Chief of Engineers*, 1872, p. 530.

Table of power at Indian Fishery shoal, Yellow river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*12.3 feet fall.*
Minimum	420	12.277	59	6.7	82
Minimum low season			76	8.6	106
Maximum, with storage			420	47.7	587
Low season, dry years			87	9.9	122

Allen's shoal has a fall of 1.8 feet in 400, not, used, and, unless a dam of considerable height could be built, of course useless. There was once, however, a mill here. The width of the stream at the head of the shoal is about 200 feet.

Lee's shoal, not improved, has a fall of 3.9 feet in 1,400. The width of the stream is about 275 feet at the head of the shoal, and the bed is exposed rock, for 400 feet, when the stream bends abruptly to the right. The power is probably available. The drainage area of the stream being but little smaller than at its mouth, the available power can be calculated from the preceding table.

Webb's shoal and Flat shoal are two shoals with small falls, and are of no value.

Dried Indian shoal, not improved, has a fall of 7.2 feet in 1,500, all of which is probably available, and could perhaps be increased by a dam. The width of the stream at the head is about 200 feet, and the bed is rock. Dried Indian creek enters below the head of the shoal. The following table gives an estimate of the power:

Table of power at Dried Indian shoal, Yellow river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*7.2 feet fall.*
Minimum	400	7.241	56	6.4	46
Minimum low season			72	8.2	59
Maximum, with storage			400	45.4	327
Low season, dry years			82	9.3	67

Cedar shoal is the next above, and is the most important one on the river, the fall being 62.6 feet in 4,875, or less than a mile. The stream is very variable in width, and the channel is interspersed with islands. At the head of the shoal the width is 290 feet, and about 300 feet below is a dam, extending diagonally across, 327 feet long and 4 feet high, of wood and stone, built in 1878 at a cost of $1,500. It is bolted to the rock, and has never been injured by freshets. It backs the water for 3 miles with an average width of 300 feet or so. A race 300 feet long leads to a cotton-yarn factory and a grist- and saw-mill on the right bank, the factory using a fall of 16 feet and 70 or 80 horse-power perhaps, and the grist- and saw-mill using a fall of 21 feet and about 50 horse-power. Full capacity can always be obtained, with a waste of water at all times. Just below the mills is a large island. The banks on the right are high and hilly near the factory and below, but not bluffy till near the foot of the island above referred to, where they are very steep and rocky, and continue so to the foot of the shoal. The entire fall could not be utilized on this bank. The left bank is not so steep or hilly, and power has been used on that side, a dam 700 feet long having been built below the island, extending diagonally across the stream, and supplying power to mills below by a race 700 feet long. No power is used here now, and the dam is almost entirely washed away. The power could doubtless best be utilized in two parts, the upper part, as now used, on the right bank, and the lower part, with a fall of 43 feet or so, on the left bank. The width of the stream below the shoal is 200 feet.

The following table contains estimates of the power:

Table of power at Cedar shoal, Yellow river.

State of flow (see pages 18 to 31).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*20 feet fall.*	*62.664 feet fall.*
Minimum	376	62.664	53	6.0	120	376
Minimum low season			68	7.7	154	482
Maximum, with storage			376	42.7	854	2,676
Low season, dry years			78	8.8	176	551

This shoal is 3 or 4 miles above Indian Fishery shoal, and 3 miles from Covington, which is the nearest railroad point. The factory above described is known as the Covington Mills (O. S. Porter).

The next shoal above Cedar shoal is Crew's shoal, at the mouth of Turkey creek. The fall is not large, perhaps 4 feet or so. The power available can be obtained from the preceding table with sufficient accuracy. Hendrick's and Meriwether's shoals follow, but are too small to be of special value. A fall of 6 feet could be obtained by a dam.

The next shoal is 5 miles above, at the crossing of the Georgia railroad, and is known as Bridge shoal. The fall is 4.3 feet in 1,000, but the principal part occurs in the first 500 feet. The power is unimproved, but formerly there was a mill there, and the remains of the dam are still to be seen. The width of the stream at the head is about 125 feet. The banks on the left are steep, the hills running close up to the river for the entire length of the shoal; the right bank is 8 or 10 feet high, of rock and clay. The drainage area above this shoal is only a little smaller than above Cedar shoal, so that the power available may be approximated by taking the power per foot fall the same as there given. All the falls thus far given may be capable of being increased by building dams.

A short distance above the bridge is the mouth of Big Haynes creek, the principal tributary of the Yellow river, and 2 miles above is Glenn's shoal, 5 miles from Conyers, with a fall of perhaps 12 feet or a little more. Four miles further up is the Rockdale paper-mill, 2 miles from Conyers, situated on a fine shoal between a quarter and a half mile in length, with a total fall of between 50 and 60 feet. The bed of the stream is rock, and the banks, though not bluffy, are sufficiently high to allow of perfectly safe locations, without much difficulty in building canals. At the head of the shoal is a dam 150 feet long and 10 feet high, built of crib-work in 1871 at a cost of about $1,000. The foundation is solid rock. The pond is 2 miles long and 200 feet wide or thereabout. At the dam, on the right bank, is a saw-mill, using a fall of 12 feet and 12 horse-power. A race 700 feet long leads on the same side to the paper-mill, where the fall is 20 feet, the water being discharged, not to the river, but to a lower race leading to a grist-mill, where the fall to the river is 13 feet. The paper-mill uses 60 horse-power, and the grist-mill 30. Below the tail-race of the grist-mill the fall is at best 15 feet in a quarter of a mile, all of which is available. Full capacity can be obtained at these mills all the time as a rule, but with very little waste of water in dry weather during running hours. The water is not drawn down in the pond during working hours. The following table gives my estimate of power at this shoal. It has served as a guide in my calculations for other shoals on the river:

Table of power at Rockdale paper-mill, Yellow river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available.	
	Sq. miles.		Cubic feet.	1 foot fall.	50 feet fall.
Minimum	222	About 50 feet.	31	3.5	175
Minimum low season			40	4.5	225
Maximum, with storage			222	25.2	1,260
Low season, dry years			46	5.2	260

This table will serve to show the available power at Glenn's mill below, the drainage area being about the same.

Six or seven miles above this shoal is Baker's mill, with a fall of 9 or 10 feet, and 2 pair of stones. Above it, but not worthy of special mention, are four other small grist-mills.

Big Haynes creek, already referred to as the principal tributary of Yellow river, drains about 85 square miles. It has a number of good small powers not used, and is said to be less variable than most of the streams in the neighborhood. It is said on good authority that it has more available powers than any stream of its size in the vicinity, and that it is an excellent stream in all respects. One of its tributaries, Little Haynes creek, has a couple of small mills, and below its mouth there is no power on the main stream, but above there are several shoals. The lowest is Kennedy's, with a fall of 28 feet, all utilized, the dam being 2½ feet high, and the race 500 feet long. The next is an unutilized power, with an available fall of about 20 feet within a distance of a quarter of a mile. Then comes a grist-mill with 16 or 17 feet; then a shoal not used, known as Indian shoal; then a grist- and saw-mill with 25 feet available and 19 feet used. Above are other and smaller powers.

It is evident from the foregoing that the Yellow river, with its tributaries, offers a large amount of very fine power. It is, in fact, one of the best streams in the vicinity, and it should not be long before more of its available power is utilized.

South river, the other of the two streams which form the Ocmulgee, rises in Fulton county, not far from the city of Atlanta, flows east into DeKalb county, and thence southeast, forming the boundary-line between Rockdale and Newton counties on its left, and Henry and Butts on its right. Its length, in a straight line, is about 45 miles, and its drainage area is 595 square miles, or greater than that of the Yellow or that of the Alcovee river. In general character, rainfall, etc., it resembles them; and, like the former, it has a number of good shoals, affording considerable power. For almost all my information regarding the water-powers on South river I am indebted to Mr. A. O. Brown, of Conyers, who is thoroughly acquainted with all the powers in the vicinity, and whose statements are entitled to the utmost reliance.

The first is Pine Log shoal, not utilized, but the fall is small, and the power unimportant.

The next is Island shoal, 5 or 6 miles from the mouth and 15 miles from Covington. The fall is about 17 feet in a quarter of a mile, all of which is available, and about 11 feet of which are used by a grist- and saw-mill, with a dam 2½ feet high. The banks and the bed are said to be favorable. The following table gives an estimate of the power, assuming the fall at 17 feet:

Table of power at Island shoal, South river.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*17 feet fall.*
Minimum	578	17	81	9.2	156
Minimum low season			104	11.8	200
Maximum, with storage			578	65.7	1,117
Low season, dry years			119	13.5	229

Three miles above is Snapping shoal, above the mouth of Snapping Shoal creek, and about 15 miles from Conyers and Covington. The available fall is 16 feet or more in a quarter of a mile, of which 14 are used by a grist- and saw-mill with a wing-dam.

Table of power at Snapping shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*16 feet fall.*
Minimum	495	16±	69	7.8	125
Minimum low season			89	10.1	162
Maximum, with storage			495	56.2	900
Low season, dry years			102	11.6	186

Above it is a shoal known as the Pearsal old shoal, now not used, but with a fall said to amount to 10 or 12 feet in a short distance. It is above the mouth of Walnut creek, and the flow is probably about four-fifths of that at Snapping shoal.

Eight miles above Snapping shoal is Peachstone shoal, above the mouth of Cotton river, a considerable stream, which enters from the south or west. It is said that a fall of 15 feet is available in one-third of a mile, of which a grist- and saw-mill and furniture shops use 10 feet.

Table of power at Peachstone shoal.

State of flow (see pages 18 to 21).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*15 feet fall.*
Minimum	253±	15±	35	4.0	60
Minimum low season			45	5.2	78
Maximum, with storage			253	28.7	430
Low season, dry years			52	6.0	90

Passing one small shoal not used, and of no value, the next power is 7 miles above Peachstone shoal, at McNite's grist- and saw-mill. A fall of about 12 feet is used, and it is said that by raising the dam 20 feet could easily be rendered available. This power is 7 miles from Conyers, and above the mouth of Honey creek.

Table of power at McNite's mill.

State of flow (see pages 18 to 21).	Drainage area.	Fall.*	Flow per second.	Horse-power available, gross.		
	Sq. miles.		*Cubic feet.*	*1 foot fall.*	*12 feet fall.*	*20 feet fall.*
Minimum	200	....	26	3.0	36	60
Minimum low season			34	3.9	46	78
Maximum, with storage			200	22.7	272	454
Low season, dry years			39	4.4	53	88

* Utilized, 12 feet; available, 20 feet ±.

The next in order is the Powell shoal, which is not utilized. It is about half a mile long, with a gradual fall for the whole distance.

The Albert shoal, 4 miles above McNite's, and unimproved, is said to have an available fall of over 18 feet. The bed is rock, and the banks good.

Four miles above is Flat shoal, where is located the cotton factory of the Oglethorpe Manufacturing Company (Robert M. Clark, president). A wooden dam, 200 or 250 feet long and 4 feet high, bolted to the rock, extends across the stream in the shape of a V, with the apex up stream. The race is 250 feet long, and on one side of the river is the factory, with a fall of 23 feet, and on the other a cotton-gin, flour- and saw-mill, with a fall of 16 feet; and there was formerly a second factory on that side, but it was burned a short time ago. It is said that the total fall available is 28 feet. The factory is a yarn-mill, with 3,000 spindles; and the one which was burned had 6,000. The flow of the stream here is considerably influenced by the fact that the city of Atlanta takes its water-supply from a point further up, pumping the water up by steam. The exact amount thus taken from the stream, however, I am unable to state. Nevertheless, Mr. Clark states that he could run all his mills, including the factory which was burned, at full capacity for nine months of the year by running 12 hours a day and drawing down the water in the pond at night. I submit no estimate of the power here for these reasons. The shoal is 16 miles from Atlanta and 7 miles from Lithonia, the nearest railroad point. The drainage area above this place is about 170 square miles. The estimates given for the shoals below this are of course almost as much liable to error as those for this one would be. As the stream is descended and becomes larger, they become less so.

There are no powers worth mentioning above this. The most important tributary of South river is Cotton river or Cotton Indian creek, which rises in Clayton county and flows east, joining the South river in Henry county. It is said to be a good stream in dry weather, and has several mills and sites. Its drainage area is about 125 square miles.

The South river, like the other streams in this region, is subject to heavy freshets. The year 1881 was remarkable in this respect, there having been no fewer than five freshets in the spring within six weeks, one of which was the heaviest in twenty years. Half of Mr. Clark's factory was carried away in the third one, with machinery and all; and the fourth one washed out his head-gates and races and part of the dam. On Cotton river one dam was carried away four times, and in the fourth freshet the mill also was carried away.

As regards the facilities for the construction of storage-reservoirs on all these streams, it is only to be said that topographically numerous suitable sites could be found, but the difficulty is, as in the case of southern streams generally, that the lands which would be flowed are the finest farming lands to be had—the bottom-lands along the streams.

Table of power utilized on the Altamaha river and tributaries.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used.
						Feet.	
Tributaries to	Altamaha	Georgia	Tattnall	Flour and grist	3	......	62
Do	...do	...do	... do	Saw	2	21	55
Do	...do	...do	Johnson	Flour and grist	2	15	24
Oconee	...do	...do	Baldwin	...do	2	12	70
Do	...do	...do	Putnam	...do	2	15	70
Do	...do	...do	Greene	Cotton factory	1	10	......
Do	...do	...do	...do	Flour and grist	3	26	104
Do	...do	...do	Clarke	...do	1	8	6
Little river	Oconee	...do	Putnam	...do	4	32	165
Do	...do	...do	...do	Saw	1	7	20
Do	...do	...do	Morgan	Flour and grist	2	22	25
Do	...do	...do	Newton	...do	2	47	30
Do	...do	...do	...do	Cotton-gin	1	25	15
Do	...do	...do	Walton	Flour and grist	1	40	45
Appalachee	...do	...do	Morgan	...do	1	20	20
Do	...do	...do	Walton	Cotton factory	1	20	100
Do	...do	...do	...do	Flour and grist	5	42	124
Do	...do	...do	Gwinnett	...do	1	22	10
Other tributaries of	...do	...do	Laurens	...do	3	34	50
Do	...do	...do	...do	Saw	2	22	50
Do	...do	...do	Johnson	Flour and grist	2	16	23
Do	...do	...do	Twiggs	...do	3	......	63
Do	...do	...do	...do	Saw	1	6	20
Do	...do	...do	Washington	Flour and grist	3	......	58
Do	...do	...do	Wilkinson	...do	12	69	140
Do	...do	...do	...do	Saw	8	40	102
Do	...do	...do	...do	Agricultural implem'ts	1	3	4
Do	...do	...do	Hancock	Flour and grist	6	94	95
Do	...do	...do	Jones	...do	4	60	98

Table of utilized power on the Altamaha river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Oconee	Georgia	Baldwin	Flour and grist	3	37	60
Do	do	do	Jasper	do	2	30	32
Do	do	do	Putnam	do	6	73	178
Do	do	do	do	Saw	1	8	25
Do	do	do	Morgan	Flour and grist	7	......	90
Do	do	do	Walton	do	6	91	122
Do	do	do	Greene	do	1	16	50
Do	do	do	do	Saw	1	23	32
Do	do	do	do	Cotton-gin	2	41	11
Do	do	do	Oconee	Flour and grist	1	22	30
Do	do	do	Oglethorpe	do	2	56	30
Do	do	do	do	Saw	4	128	100
Do	do	do	Gwinnett	Woolen	1	16	12
North Oconee	do	do	Clarke	Cotton factory	2	32	330
Middle Oconee	do	do	do	do	1	20	100
North and Middle Oconee and tributaries.	do	do	do	Saw	1	12	10
Do	do	do	do	Paper	1	16	75
Do	do	do	do	Flour and grist	4	52	82
Do	do	do	Gwinnett	do	2	32	26
Do	do	do	do	Saw	1	12	12
Do	do	do	Madison	Flour and grist	2	29	13
Do	do	do	Hall	do	11	170	130
Do	do	do	do	Saw	1	16	15
Do	do	do	Jackson	do	8	146	141
Do	do	do	do	Flour and grist	13	201	187
Do	do	do	do	Cotton-gin	5	82	70
Do	do	do	do	Leather	1	30	16
Do	do	do	do	Woolen	1	8	6
Ocmulgee	Altamaha	do	Monroe	Flour and grist	1	12	......
Do	do	do	Jones	do	1	12	......
Do	do	do	Butts	do	4	48	103
Do	do	do	do	Saw	1	12	40
Do	do	do	Jasper	Woolen	1	12	6
Do	do	do	Henry	Flour and grist	2	34	14
Tributaries of	Ocmulgee	do	Wilcox	do	1	6	4
Do	do	do	do	Saw	1	6	24
Do	do	do	Dodge	Flour and grist	1	......	10
Do	do	do	Pulaski	do	5	45	46
Do	do	do	do	Woolen	1	9	6
Do	do	do	do	Saw	1	9	15
Do	do	do	Houston	do	3	25	46
Do	do	do	do	Flour and grist	10	......	186
Do	do	do	do	Cotton factory	1	12	60
Do	do	do	Twiggs	Flour and grist	1	8	11
Do	do	do	Crawford	do	3	36	90
Do	do	do	Bibb	do	1	9	20
Do	do	do	do	Saw	1	9	30
Do	do	do	do	Cotton-gin	1	13	8
Towaliga	do	do	Monroe	do	1	9	12
Do	do	do	do	Saw	1	11	15
Do	do	do	do	Flour and grist	3	39	76
Do	do	do	do	Wool-carding	1	5	4
Do	do	do	Henry	Flour and grist	2	100	120
Do	do	do	do	Saw	2	30	36
Alcovee	do	do	Newton	Cotton factory	1	6	20
Do	do	do	do	Flour and grist	2	30	40
Do	do	do	do	Saw	1	19	15
Do	do	do	do	Cotton*	1	12	......
Do	do	do	Walton	Flour and grist	2	66	18
Do	do	do	Gwinnett	do	3	34	54
Do	do	do	do	Wheelwrighting	1	14	5
Yellow river	do	do	Newton	Cotton factory	1	16	76
Do	do	do	do	Paper	1	20	60
Do	do	do	do	Flour and grist	1	21	25

*Newton factory—not now in operation.

Table of power utilized on the Altamaha river and tributaries—Continued.

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power used.
						Feet.	
Yellow river	Ocmulgee	Georgia	Newton	Saw	2	......	80
Do	do	do	Rockdale	Flour and grist	2	24	70
Do	do	do	do	Saw	1	14	10
Do	do	do	do	Cotton-gin	1	14	10
Do	do	do	do	Furniture	1	14	10
Do	do	do	De Kalb	Flour and grist	1	7	15
Do	do	do	do	Cotton-gin	1	7	6
Do	do	do	Gwinnett	Flour and grist	6	66	126
Do	do	do	do	Furniture	1	8	10
Do	do	do	do	Saw	1	14	15
South river	do	do	De Kalb	Cotton factory	1	23	......
Do	do	do	Henry	Flour and grist	1	8	20
Do	do	do	do	Agricultural implem'ts	1	9	3
Do	do	do	do	Furniture	1	9	3
Do	do	do	do	Saw	1	9	20
Do	do	do	Newton	do	1	30	10
Do	do	do	do	Flour and grist	1	30	25
Do	do	do	Rockdale	do	2	24	39
Do	do	do	do	Cotton-gin	1	16	4
Do	do	do	do	Furniture	1	9	6
Do	do	do	De Kalb	Flour and grist	2	35	65
Do	do	do	do	Saw	1	10	15
Do	do	do	do	Cotton-gin	1	10	12
Do	do	do	do	Furniture	1	10	5
Do	do	do	Fulton	Saw	1	22	9
Do	do	do	do	Flour and grist	2	34	24
Do	do	do	do	Cotton-gin	1	22	9
Other tributaries of	do	do	Pike	Flour and grist	2	74	55
Do	do	do	Monroe	do	11	157	148
Do	do	do	do	Saw	1	11	9
Do	do	do	do	Cotton-gin	1	11	5
Do	do	do	Henry	Flour and grist	3	78	38
Do	do	do	do	Saw	2	33	23
Do	do	do	Butts	Flour and grist	4	52	45
Tributaries of	South	do	Henry	do	3	119	26
Do	do	do	do	Saw	1	10	10
Do	do	do	do	Woolen	1	......	5
Do	do	do	Clayton	Flour and grist	2	36	33
Do	do	do	Rockdale	do	3	62	18
Do	do	do	do	Saw	1	18	6
Do	do	do	do	Cotton-gin	2	31	22
Do	do	do	do	Leather	1	8	4
Do	do	do	Newton	Flour and grist	1	30	12
Do	do	do	De Kalb	do	10	181	128
Do	do	do	do	Saw	3	44	30
Do	do	do	do	Cotton-gin	6	108	54
Do	do	do	do	Paper	3	99	152
Do	do	do	Newton	Leather	1	15	20
Do	do	do	do	Cotton-gin	1	15	15
Do	Yellow	do	do	Flour and grist	2	37	18
Do	do	do	do	Cotton-gin	1	12	8
Do	do	do	Rockdale	Flour and grist	3	70	73
Do	do	do	do	Saw	1	......	13
Do	do	do	Walton	do	1	15	8
Do	do	do	do	Flour and grist	3	35	22
Do	do	do	Gwinnett	do	2	51	10
Do	do	do	De Kalb	do	2	26	25
Do	do	do	do	Saw	2	55	20
Do	do	do	do	Cotton gin	2	32	33
Do	do	do	do	Furniture	1	15	3
Do	Alcovee	do	Walton	Flour and grist	1	18	8
Do	do	do	Gwinnett	do	2	54	32
Do	do	do	do	Cotton-gin	1	15	5
Do	do	do	do	Saw	1	18	20

XII.—THE STREAMS SOUTH OF THE ALTAMAHA.

These streams offer so small an amount of power that they are not worthy of special mention. None of them reach above the fall-line, so that they have no falls of importance, the larger ones being generally sluggish and navigable, and bordered by swamp-lands. Some of the smaller ones may be classed as sand-hill streams, and offer some power, which is utilized to a certain extent by saw- and grist-mills, and it may be that on some of them moderately large powers could be developed. There are no powers in Florida which are worthy of special mention, and the tables of power show that there is only a small amount of power used in the state. There is only one point which it is interesting to notice in this connection, namely, the amount and distribution of the rainfall in the peninsula. The average fall in spring is about 9 inches over the whole peninsula, or not more than in the New England states; but in summer it is greater than in any other part of the Union, ranging from 18 to 26 inches. In autumn the fall is still large, varying from 10 to 14 inches, while in winter there is only between 8 and 10 inches fall, or considerably less than in some parts of New England. This distribution of the rainfall must have for its effect a very uniform flow in the streams, and it does not seem improbable that they may even be lowest in winter, like some of the western streams, instead of in summer and autumn, like the other streams on the Atlantic slope; but I have nc data with which to test the truth of this supposition.

CONCLUDING REMARKS.

In glancing over the previous pages one cannot fail to be struck with the very large amount of power remaining unutilized in the middle and western parts of the region we have been considering. That this power is very large the numerical data which have been given leave no room to doubt; that a very large amount is practically available is also evident; but it will perhaps add to the clearness of these two facts if we devote a few lines here to a brief recapitulation of the principal general results to which we have been led.

We have seen that, leaving out of consideration the eastern, or navigable, district, the topography of the region is very favorable for power; that the rivers have steep declivities, and that they often have cataracts or rapids of considerable magnitude. If we compare the declivities of the southern streams with those of streams in the middle states and in New England, we shall find, in fact, that the former are at least as great, and probably greater, than the latter. We have seen that the elevation of the Atlantic plain at the foot of the mountains is greater in the region we have considered than anywhere else along the Atlantic coast, and that the slope of that plain does not vary correspondingly from north to south; and we have found, as would be expected, that the streams, in their course across this plain, from the mountains to the sea, develop an enormous amount of power. And of this total power, much of which is necessarily unavailable, we have, nevertheless, found that a large amount can be developed and utilized if desired, on account of the ledges of rock across which the streams flow, and the falls and rapids which they occasion. But, while the southern streams are confined entirely to the Atlantic slope of the mountains, taking their rise on the extreme eastern ridge of the system, many of the streams in the middle states have their sources far to the west, nearly or quite on the other side of the system. Topographically, then, the chief difference between the northern and the southern streams is the fact, that in the case of the former the greater part of their drainage-basins is included in the western or mountainous district, and the smaller part in the eastern or tide-water district; while in the case of the latter the reverse is true, and the eastern district extends far above the head of tide-water. There is one respect in which this difference in configuration acts unfavorably on the water-powers of the south, namely, as regards transportation, for not only does the large extent of the eastern district render navigation of the rivers difficult, and transport by sea less easy than in the north, but the railroads, in the water-power district, are not so constrained to follow the river valleys as in the case of the northern streams, which often flow between parallel ranges of hills, so that the most convenient and economical location for a road, and often the only practicable one, is along their banks. In the southern states, on the contrary, we often find the railroad following the divides, instead of the water-courses, and the consequence is that many of the finest water-powers are at present very inaccessible. But it is evident that the evil is of a kind which is easily remedied, and which will be remedied as soon as the manufacturing interests of the region demand it. We have seen that the beds of the streams are everywhere favorable for the construction of dams, and that the banks are generally favorable for the construction of canals and buildings at the points where the water-powers occur.

As regards the flow of the streams, we have been altogether without data derived from actual measurement, and have been obliged to draw our conclusions from a study of the circumstances influencing flow. We have seen that the southern states are probably better wooded than the middle or New England states; that the soil is deep, and quite pervious, although shedding sudden showers with considerable rapidity; and that the mountains are wooded and covered with soil; all of which circumstances act to render the flow of the streams constant. And the topography is also favorable in this respect, for we shall see that in the case of the James and the Potomac rivers,

which drain a large extent of mountain region, consisting of parallel and narrow valleys between high hills, such a configuration is favorable to the sudden discharge of rain-water, and that those two streams are therefore probably much more variable in flow on this account than they would otherwise be. We have seen, further, that the principal carriers of moisture in the district we have considered are the winds from the Gulf of Mexico and from the Atlantic, but principally the former. In the summer these winds are deflected from their normal northeasterly course by the tendency of the atmosphere to move toward the heated continent, and winds from the south and southeast are more frequent than at any other season; and these winds, reaching the coast either directly from the sea or after having passed over only a small extent of low land, deposit a considerable portion of their moisture, the rainfall decreasing as we proceed inland, until what remains is condensed by the lofty mountains. In the winter, on the contrary, the winds which bring the rain, being mostly from the southwest, deposit the greater part of their moisture on the mountains and the high ground in the middle region, so that the rainfall is small on the coast. Just here lies a most important difference between the rainfall in the south and that in the middle and New England states, for while in the latter the rainfall in summer always exceeds that in winter, in the middle and western parts of the former it is sometimes greatest in winter, and rarely greatest in summer. If we exclude from consideration a few streams, like the James and the Potomac, whose flow is probably rendered variable to a large extent by the topography of their drainage-basins, the conclusion seems justified that the flow of the southern Atlantic streams is more variable than that of streams in the New England and the northern part of the middle states; and this statement is further strengthened by the entire absence of lakes in the southern states. In so far, then, the water-power of the south is inferior to that in the north; but we have also seen that the rainfall in the south is often very much greater than in the north, and it is therefore probable that these two circumstances offset each other to some extent.

We have further seen that, as regards freshets, although some of the southern streams, like the Cape Fear and the Roanoke, are subject to very heavy ones, the southern streams, as a rule, do not compare unfavorably with those in the north. In the great freshet of 1854 the Connecticut river rose 29 feet 10 inches at Hartford, which would be an extraordinary rise for most of the southern streams. The trouble in the south as regards freshets lies in the fact that on the large streams such large areas of bottom land are subject to overflow, a drawback which is no doubt felt more than in the north, and which, combined with the large width of the streams, has probably prevented the utilization of more than one power.

We have seen a great advantage of the water-power in the south to lie in the fact that the streams never freeze over, and that there is scarcely any trouble with ice or ice freshets. We have come to the conclusion that the disadvantages of the higher mean temperature have been exaggerated, and we have seen that it is in many respects a very favorable circumstance. As regards the increased evaporation, we could not form any definite ideas.

In view of these facts, then, may we not, from a purely technical point of view and without reference to manufacturing advantages, answer in the affirmative, and with emphasis, the question whether or no the advantages for the utilization of water-power in the southern Atlantic states are fine? I think it must be acknowledged that they are, in many respects, as good as could be desired; and when we consider the advantages offered in those states for particular manufactures, like that of cotton, it would seem that the time cannot be far distant when these powers will be turned to account.

In closing this report, I must once more take occasion to caution the reader against supposing that the estimates of power which have been given can pretend to exactness. Although four states of flow have been distinguished, and the estimates may therefore present an appearance of accuracy and detail, this distinction has been made merely with the object of conveying definite ideas, and of leaving no room for misunderstanding in regard to what was meant, it being thought essential to accomplish this end, even at the risk of giving the estimates an appearance of accuracy which they do not, and cannot, possess.

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REPORT ON THE WATER-POWER

OF THE

EASTERN GULF SLOPE,

BY

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SPECIAL AGENT.

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BOSTON, MASS., *July* 9, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York, N. Y.

SIR: I have the honor to submit a report upon the water-power of the eastern Gulf slope, based upon investigations carried on under your direction during the spring of 1881. Sufficient time was at command for only a hasty reconnaissance of some of the more important streams, which is the more to be regretted as this section was found to be extremely attractive, not only by reason of its extensive and varied natural resources, including a large amount of available water-power, but also because of the frequent evidence that was met of an increasing interest in the development of those conditions. It is desired to call attention to the principles observed in the estimates of flow and power, which are fully explained in connection with the report on the region tributary to Long Island sound.

Very respectfully,

DWIGHT PORTER.

THE EASTERN GULF SLOPE.

Although the section thus indicated might properly embrace all the gulf slope east of the Mississippi river, it is here for convenience limited to that portion east of and including the basin of the Alabama river. As thus defined it stretches over 600 miles along the coast, from Mobile bay to cape Sable, and extends inland a distance varying from about 80 miles in the Florida peninsula to 350 miles in northern Georgia, comprising an area, in round numbers, of 92,000 square miles. The principal rivers are, in order from the west, the Alabama, Perdido, Escambia, Yellow, Choctawhatchee, Appalachicola, Ocklockonee, Ocilla, Suwannee, Withlacoochee, Hillsborough, Chilocohatchee, and Caloosahatchee, with their affluents. But of these main rivers only the Alabama and Appalachicola reach, through thier tributaries, far enough inland to include within their basins any important water-powers. The remainder are comparatively sluggish, and are bordered by lowlands subject to overflow. They drain a region accessible only to a limited extent by railroad, and find but little use except for the rafting of timber, and, where navigable, a small amount of transportation of lumber and agricultural products. They are usually obstructed by snags and shoals, but in most cases have been surveyed and found susceptible of improvement for navigation at moderate expense.

The land along the immediate coast is often swampy, and in Florida seems to retain that character even to the upper waters of the streams. In the cases of those streams heading in southern Georgia swamps are less noticeable, but yet frequently border their courses, even 50 miles or more from the Gulf. Although this region evidently can have but little value for water-power, that resource is not entirely lacking, and it is asserted that there are numerous short streams, reaching back but a little way from the coast, which are nevertheless characterized by a remarkably full and uniform flow, and, being often navigable to the very points where it would be natural to improve them by dams, offer unusual advantages for small powers. They are clear streams, running over sandy beds, and are free from dangerous rises. A striking example of this class is found in the case of bayou Minette, which empties into the bay directly opposite the city of Mobile. It heads back but little more than a dozen miles and drains only 72 square miles, yet near the mouth a framed dam has been built on a pile foundation, and a fall of 10 feet obtained, with a minimum, it is claimed, of not far from 200 horse-power. By the power thus secured there are run a cotton factory of 2,000 spindles, a woolen factory of 50 looms, and a saw-mill. Navigation extends directly to the dam.

Receding northward from the Gulf, the land gradually rises, and in Alabama to a distance inland of 100 or 125 miles we are upon the Tertiary formation. In Georgia this reaches still farther to the north, and, excepting a narrow strip in the west, is limited approximately by a line running from Columbus northeasterly through Macon to Augusta. This southern division is distinguished by a gently-undulating surface, a thin sandy soil, capable, however, of easy and great improvement, an extremely healthful climate, and perhaps is most noted as including the great pine-belt. Almost everywhere there is a magnificent growth of the long-leafed pine, with much hard wood also intermingled. The cutting and rafting of timber is an active and growing industry along most of the streams, but has not yet been in general so far prosecuted as seriously to diminish the supply.

The northern limit of this belt in Alabama does not attain an elevation of more than 350 or 450 feet. It is succeeded to the north by the Cretaceous formation, which stretches from west to east across the state but extends not over 30 miles into Georgia. In Alabama this formation has a general width from north to south of about 50 miles, and constitutes the so-called cotton-belt. It is but moderately timbered, and is in fact a prairie region with a level or gently-undulating surface. The black soil is underlaid by the rotten limestone, is heavy and calcareous in nature, splendidly adapted to the production of cotton and corn, and also yields well in tobacco, potatoes, various small grains, and grasses. The climate is less healthful than either to the north or to the south, there being a liability to fevers in summer and autumn. Springs are almost entirely lacking. The streams rise quickly after rains and then rapidly sink away, and often go nearly or quite dry.

Passing beyond this belt still farther north we come upon the elevated and mountainous portions of Alabama and Georgia, the region in which principally lie their resources in the way of water-power. The great Appalachian system which follows down the Atlantic coast throws out spurs into these states, reaching well toward, and at

points even below, their centers, and giving to the streams hard enduring channels in which to flow, and rapid fall. The southern boundary of this elevated section, geologically known in Alabama as the Middle region, and geographically subdivided in Georgia into the Middle and Northern regions, may very well be shown by a curving line passing from Fayette, in northwestern Alabama, southeasterly through Tuscaloosa, Centerville, Wetumpka, Tallassee, and on to Columbus, Georgia, and thence in an approximately straight course northeasterly to Augusta. In Alabama the line which should mark the boundary between this region and the cotton-belt, or Cretaceous formation, already described, is covered by a belt of stratified drift material—gravels, sands, and clays—stretching in an east-and-west direction across the state, with a width, transversely, varying from 5 to 40 miles. This belt is well supplied with springs, and contains numerous short streams, of which Autauga county furnishes notable examples, that are finely suited to powers of moderate size.

The average elevation of the mountainous portions of Alabama and Georgia would be difficult to state with much accuracy. What is described as the Middle region of Georgia, the southern boundary of which has been defined, and the northern limit of which is roughly shown by an east-and-west line through Atlanta and Athens, is estimated to have an average altitude above the sea of 750 feet, which is also given for northwest Georgia, lying to the west of the Cohutta range. Northeastern Georgia, extending from the Cohutta range easterly to the Savannah and Tugaloo rivers, has an estimated mean elevation of 1,500 feet, and includes peaks which attain heights of nearly 5,000 feet. In the metamorphic region of eastern Alabama the general elevation is said to lie between 800 and 1,200 feet.

The natural resources of this section are wonderful in extent and variety, and are as yet but slightly developed. The bituminous coal which is found is confined mainly to Alabama, where it covers a vast district in the northern central part of the state, embracing, it is estimated, 5,500 square miles. Three principal fields are recognized—the Warrior, Coosa, and Cahaba—the first including of itself about 5,000 square miles. The Coosa coal-field stretches northeasterly along the river of the same name, and its prolongation in Georgia takes in the three counties of Dade, Walker, and Chattooga; otherwise Georgia is without deposits of coal. Magnificent beds of iron ore occur throughout northeastern Alabama and northern Georgia, and in the former state there are at certain localities combined the unusual advantages of ore, coal, and limestone within a short distance on either side of a single valley. Gold is largely and profitably mined in the section drained by the upper Tallapoosa river in eastern Alabama and the adjacent portion of Georgia, and in the upper basins of the Etowah and Chattahoochee rivers in northeastern Georgia. Copper, lead, asbestos, and other minerals are also found.

In describing the elevated portions of these states it is especially important, with reference to their water-power, to notice the boundaries of the metamorphic formation. In Alabama, it is confined within a line drawn as follows: From Columbus on the Chattahoochee river, westerly through Tallassee to Wetumpka, thence northerly, a little west of the Coosa river, nearly to Shelbyville; the boundary line then turns to the northeast toward Georgia again, and follows the general course of the Selma, Rome, and Dalton railroad, but distant from it from 5 to 10 miles southward, until it reaches the state line. In Georgia, the metamorphic region includes every thing north of a line running from Columbus to Augusta, excepting eight or ten counties in the extreme northwest corner of the state. While the coal districts that have been noticed have a sandy and loamy soil, difficult to improve, easily washed, and with little agricultural value, the metamorphic region has a large amount of fine farming land, the staple productions of which are cotton in the less elevated sections, corn, wheat, oats, rye, barley, clover, grasses, fruits, and vegetables. The soils are red and gray, with clay subsoil. Building-materials, including granite and gneiss, abound, and there is some marble. The hills are covered with splendid oak forests, besides which pine, ash, elm, walnut, and hickory are common. Springs and clear running streams are everywhere plentiful, and the climate is very healthful.

The southern boundary of the metamorphic formation is very clearly indicated by a series of shoals, rapids, and falls, which fill the courses of the principal streams as they cross its borders and finally escape from its firm grasp. These falls mark the head of navigation, and constitute some of the finest water-powers in the South. On the streams to be considered they occur in the Coosa at Wetumpka, there being a descent of 80 feet in 12 or 15 miles above the city; on the Tallapoosa at Tallassee falls, where there is a fall of 52 feet in 300 feet, and a total of 84 feet in about 2 miles; and on the Chattahoochee at Columbus, where within 4 or 5 miles the descent is 120 feet. Generally speaking, the larger streams are free from abrupt falls of much magnitude, these being much less common than on rivers of corresponding size in New England and New York, and their descent is accomplished, above the fall-line, by rapids and occasional low pitches.

These rivers may be contrasted with those of the northeastern states, which elsewhere come within this report, in three important respects—fall, volume, and accessibility. As just noticed, the fall is usually less concentrated, and is, accordingly, less attractive for improvement than in the latter section. Excepting Tallassee and Columbus, there are no falls on the main portions of the larger rivers under discussion to be compared with those occurring on the Connecticut and Housatonic rivers in western New England, and on the Hudson, Black, and Genesee rivers in New York state.

As regards the steadiness with which their volumes are maintained in the dry season, there are but few reliable data to be found for the water-power streams of the eastern Gulf slope, and such as do exist indicate a considerable

range in value among different ones; it appears probable, however, that as a class they are in this respect, also, at some disadvantage as compared with the manufacturing rivers of the New England states and New York. There are scarcely any records of long series of observations upon temperature and rainfall in northern Georgia and Alabama within the limits of the region we are considering, but some idea as to those phenomena may perhaps be gained from the following table, compiled from the Smithsonian publications. For the sake of comparison, two points on the immediate gulf coast are added, and several in the northeastern states:

Table of rainfall and temperature.

Locality.	Elevation above sea.	RAINFALL.						TEMPERATURE.					
		Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.	Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
	Feet.		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		°	°	°	°	°
Atlanta, Georgia	1,050	9	14.69	12.42	10.56	15.13	52.80	5	58.27	74.87	58.44	41.86	58.36
Coosa basin above Wetumpka (*a*)	....	....	14.50	14.00	10.00	15.50	54.00	....	60.00	76.00	60.00	41.00	59.00
Tallapoosa basin above Tallassee. (*a*)	....	....	14.00	13.50	10.50	14.50	52.50	....	61.00	75.00	66.00	44.00	61.00
Chattahoochee basin above Columbus. (*a*)	....	....	12.50	13.00	9.50	14.00	49.00	....	58.00	74.00	58.00	42.00	58.00
Mobile, Alabama	15	5	16.62	21.21	11.42	13.40	62.65	10	66.87	79.00	66.27	52.43	66.14
Cedar Keys, Florida	35	10	5.50	20.43	11.76	8.09	45.78	11	69.64	81.05	71.70	57.87	70.06
Springfield, Massachusetts	200	12	11.09	12.52	11.72	8.85	44.18	9	46.46	71.40	50.72	26.24	48.71
Claremont, New Hampshire	539	8	11.92	12.11	10.44	9.08	43.55	9	43.09	67.01	47.37	21.50	44.74
Albany, New York	130	36	9.69	12.34	10.50	8.03	40.56	46	46.54	70.43	49.56	25.26	47.95
Rochester, New York	500	44	8.05	9.12	9.27	7.21	33.65	38	44.72	68.04	49.02	26.46	47.06

a Estimated.

The average temperature is greater in the water-power region of the gulf states than in New England and New York, being at Atlanta from 10 to 14 degrees more for the year than at the northern cities mentioned, and it seems probable that the annual loss by evaporation is rather greater in the former section than in the latter. The annual rainfall on the three basins of the Coosa, Tallapoosa, and Chattahoochee rivers exceeds that on most of the New England streams, but its distribution through the year is less favorable. As may be seen from the table below, the downfall on the interior region of the gulf slope is least in summer and autumn, when it ought to be greatest in order to meet the draughts made by evaporation, while at the north the least precipitation is in winter and spring.

Table showing relative distribution of rainfall during the year.

Locality.	Mean annual rainfall.	Rainfall, winter and spring.	Ratio to mean annual rainfall.	Rainfall, summer and autumn.	Ratio to mean annual rainfall.
	Inches.	*Inches.*		*Inches.*	
Atlanta, Georgia	52.80	29.82	0.56	22.98	0.44
Coosa basin above Wetumpka (*a*)	54.00	30.00	0.56	24.00	0.44
Tallapoosa basin above Tallassee (*a*)	52.50	28.50	0.54	24.00	0.46
Chattahoochee basin above Columbus (*a*)	49.00	26.50	0.54	22.50	0.46
Mobile, Alabama	62.65	30.02	0.48	32.63	0.52
Cedar Keys, Florida	45.78	13.59	0.30	32.19	0.70
Springfield, Massachusetts	44.18	19.94	0.45	24.24	0.55
Claremont, New Hampshire	43.55	21.00	0.48	22.55	0.52
Albany, New York	40.56	17.72	0.44	22.84	0.56
Rochester, New York	33.65	15.26	0.45	18.39	0.55

a Estimated.

The streams at the South are free, it is true, from the dangerous ice-freshets which sometimes occur farther north, but they are subject during winter and spring to freshets caused by heavy rains, and in their less rapid portions are at such times visited by rises which are almost unparalleled on the streams with which they are being contrasted. The Coosa has reached a height of 54 feet above low water at the head of navigable waters at Wetumpka; the Chattahoochee has been known to rise 42 feet at Columbus below the falls, and at points on the river above the extreme oscillations have ranged from 25 feet down, according to locality. In its upper course, even, the Flint river is said to have risen 25 feet in the spring of 1881. On the other hand, the highest freshet-rise ever known in the Connecticut river at Hartford, entirely below all the falls, and where the ordinary slope is extremely small, with a tributary drainage area above of over 10,000 square miles, did not exceed 30 feet.

The southern streams which we are discussing are at a disadvantage in another important condition, namely, the opportunities for extensive storage in one season to meet the demands of another. There seems to be for this

purpose an entire absence of large natural lakes, ponds, and swamps, which are of such value as regulators of flow, even when unimproved, and which acquire great additional importance when capable, as they usually are in New England, of being raised and controlled by dams. Of course, the ordinary mill-dams along a stream hold back, in the aggregate, a large amount of water; but as to facilities for storing extensive supplies in spring for use during summer and autumn, such as exist throughout New England and northern and central New York, they appear to be entirely lacking on the eastern gulf slope. It is, to be sure, conceivable that in the latter section dams should be thrown across the valleys of the minor streams, and artificial storage reservoirs of the character mentioned thus be formed; but, unless by this means an unusual widening of a valley where there is an expanse of swampy or otherwise worthless land can be overflowed, the expense and danger of improvements are usually out of proportion to the storage obtained, and would not be attempted on an important scale.

In the third place, the streams tributary to the Gulf in Alabama and Georgia are by no means so conveniently accessible as would in New England be considered essential to a suitable development of their water-power. The head of navigation on the Alabama river is over 300, and on the Chattahoochee 400 miles from the Gulf. There are numerous well-equipped lines of railroad, and many more will in the future be built, but the present lines do not usually reach directly the streams in those portions where there is valuable power. Sometimes they follow the water-sheds, and again they run parallel to the rivers, but at distances of from 5 to 25 miles, near enough to discourage the building of new roads, and yet far enough away to render necessary a vexatious amount of transfer by teams. Spurs can be run to the streams, but they would accommodate only limited sections.

What has been said is not intended to detract in the least from the manifestly great value for power of the streams of upper Georgia and Alabama. While perhaps wanting in certain advantages enjoyed by the rivers of other sections, they offer many magnificent powers and are surrounded by almost unexampled agricultural and mineral resources. Especially for the manufacture of cotton and woolen goods do the conditions seem favorable; and that the fact has become recognized is proved by the frequent construction of new mills and by the encouragement given by the state of Georgia to such enterprises. By an act of the legislature passed in 1872, it was declared that—

> Any mill or mills within said state, for the manufacture of fabrics out of cotton or wool, or both, whether such investment be applied in the establishment of a new factory or in the extension or enlargement of a now existing factory, shall be exempt from taxation for state, county, and municipal purposes, on the capital so invested, and on any property purchased or erected therewith, intended for and necessary to such manufacture, for the term of ten years from and after the laying of the foundation of the mills so to be erected.

Without going into a discussion of the relative advantages for cotton-manufacturing of the South and of New England, it is evident that a great, and possibly the most prominent, point in favor of the former is the fact that the cotton factories and sources of supply of the raw material are brought very close together. The climate is equable and mild, and on account of its humidity is favorable to certain of the processes of manufacture. While the summer temperature is claimed not to be so great in northern Alabama and Georgia as to be enervating, the absence of severe cold in the winter season materially reduces the cost of heating factories and the living expenses of operatives. As a rule, the labor in the mills is now performed by native whites, who are said to work contentedly long hours for low wages, without a thought of organizing strikes. As to whether this state of things will continue unchanged after manufacturing has become more developed here, and even as to whether the hands employed are as efficient as a similar class of labor at the North, there may be some question. The profits earned in late years by the Georgia and Alabama mills, usually exceeding 20 per cent. per annum, are a very good indication that cotton-manufacturing in those states is a successful industry.

THE ALABAMA RIVER AND TRIBUTARIES.

THE ALABAMA RIVER.

This important river is formed a short distance above Montgomery, Alabama, and somewhat southeast of the center of the state, by the union of the Coosa and Tallapoosa rivers, its principal tributaries. It runs westerly and then southwesterly, passing through or bordering upon the counties of Elmore, Montgomery, Autauga, Lowndes, Dallas, Wilcox, Monroe, Clarke, and Baldwin; about 50 miles by water from Mobile it joins the Tombigbee to make up the Mobile river, which flows southerly into the bay of the same name.

The Alabama river comprises in its drainage basin 23,700 square miles, of which 17,970 lies in Alabama, 5,620 in Georgia, and a little over 100 square miles in Tennessee. It is 150 miles long by general course, but is a very tortuous stream, and taking into account the bends has a length by survey of 312 miles.(a) Along its borders are rich alluvial lands, and large tracts of timber are also accessible from the river and its tributaries. Navigation extends throughout the year for boats of not over 3 feet draught, and during the high water of fall and winter is open

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a According to Berney's *Hand-book of Alabama.*

to almost any draught. The principal obstructions are bars and snags, and to remove these and to provide a navigable channel of 4 feet depth in low water, and a minimum width of 200 feet, plans have been developed under the direction of Captain A. N. Damrell, Corps of Engineers, U. S. army. The improvement described is designed to extend over the entire length of the river, to Wetumpka on the Coosa, and is estimated to cost $230,000. From 1878 to 1881, inclusive, $100,000 was appropriated by Congress to this work, which has steadily been prosecuted. The principal points on the river are Montgomery, population 17,000, and Selma, 7,500. Steamers ply regularly between Montgomery and Mobile, and transport large amounts of cotton, lumber, and other products. Mobile has, in round numbers, 30,000 inhabitants, and though the business at that point in cotton has declined from the prominence once enjoyed, a fine trade in lumber is said to be growing up.

In 1875 the flow of the river was gauged at a point some 28 miles below Montgomery, by Mr. Gavin B. Yuille, United States assistant engineer. The measurement was made at a stage about 1 foot above ordinary low water, and gave a discharge of 3,711 cubic feet per second. The drainage area at the locality of gauging being about 16,650 square miles, the above discharge corresponds to 0.22 cubic foot per second per square mile. The river is subject to heavy oscillations from freshets, and there is reported to have been in 1874 a rise near the mouth of 20 feet above low-water mark, increasing farther up stream, and reaching between 50 and 60 feet on the Coosa river a little way above the head of the Alabama.

TRIBUTARIES OF THE ALABAMA RIVER.

With the exception of the Coosa, Tallapoosa, and Cahaba, the Alabama river has no large tributaries; but flowing into it at various points are creeks which appear unimportant on the map, but which really carry considerable water and would prove reliable for powers of moderate size. At present they are used only in a small way by occasional saw-mills, grist-mills, and cotton-gins. Very few of them are conveniently reached by railroad, and no special information as to their fall or volume is at hand.

Those south of the latitude of Camden lie in the pine-belt, the country being covered with a splendid growth of long-leafed pine. The surface is hilly, the soil is light and sandy and well suited to the production of fruit and vegetables. The climate of the higher lands is healthful; springs abound and the streams are well sustained.

Lowndes and Dallas counties are in the cotton-belt, and some idea may perhaps be formed of the streams draining them from the nature of the country. The surface is comparatively level, with a rich black soil, a moderate amount of timber, and but few springs. Cotton and corn are the main products, but the soil also does well with wheat, rye, oats, tobacco, potatoes, barley, buckwheat, sugar-cane, millet, and grasses. Some limestone answering fairly well for building and burning is said to be found. The streams are scarcely at all used for power, and are probably unreliable.

In Autauga county there are several streams which are used to some extent by saw- and grist-mills, while at Prattville and Autaugaville there are cotton factories. The streams here referred to would doubtless furnish numerous good privileges; Autauga and Swift creeks were especially mentioned as valuable, but the others are close at hand and presumably possess the same general features. The main courses lie within the so-called cotton-belt, but the Autauga County streams differ from the prairie streams of Montgomery, Lowndes, and Dallas counties in that they are upon a strip of gravel, sands, and clays, which follows along the northern border of the cotton-belt, and which is well supplied with springs, thus contributing to their steadiness.

Autauga creek is perhaps a good representative of the streams just mentioned. It runs southerly through Autauga county, and empties into the Alabama river 8 miles west of Montgomery. It is not over 25 miles long, and drains 125 square miles, the country having a tolerably level surface, well timbered with pine. The creek has a moderate current and flows between rather low banks; its bed is sandy and its water is very clear and pure. At Prattville the average width is perhaps 40 feet. The volume is remarkably well maintained, owing to the presence of many springs in the section drained, and scarcely any hinderance is experienced at Prattville, the principal point where power is used, from either low or high water.

On the upper course of the creek there are small saw-mills, but the timber near at hand has largely been cut away. Quite an important power, however, is in use at Prattville, a thriving place of 1,000 inhabitants, about 12 miles from Montgomery, with which it is connected by rail. Manufacturing was begun here about the year 1845, and four establishments are now run by the water-power of the creek. The Prattville Cotton Manufacturing Company makes coarse white ducks, and has made, and still has the facilities for making, sheetings and shirtings. The company employs 140 hands, native whites mostly, and runs 128 looms and 5,600 spindles. The Daniel Pratt Cotton Gin Company has quite extensive works, and there is also a sash-and-blind shop and a small grist-mill. All of these concerns are run from the same privilege, using together about 250 horse-power with a fall of 17½ feet. The supply of water is sufficient at all times of the year for running at full capacity, though there is not much surplus in a low stage.

The dam was built at least 30 years ago, and is of brick laid in cement. It rests on a bed of marl, is 150 feet long, 12 or 15 feet high, 18 feet wide at the base and 3 feet wide at the top. A plank apron protects the stream-bed, and the dam is surmounted for its whole length by a stout timber bulkhead containing waste-gates. The pondage above the dam is estimated at 30 acres.

A short distance up stream there is an unoccupied fall of 8½ feet, formerly in use; the mill was burned, but the dam remains. A little way below the Prattville factory a 3-set woolen-mill has a fall of 5 feet, but was not in

operation at the time it was visited. Swift creek, to the westward, in the same county, is reported to have a larger volume than Autauga creek, which might be expected from the fact that its drainage area is a third greater.

Minor tributaries of the Alabama river.

Name of stream.	Drainage area.	Remarks.
	Sq. miles.	
Autauga creek	125	These lie in Autauga county mainly, in a district well supplied with springs, and are good streams, with clear waters and well-maintained volume.
Swift creek	163	
Little Mulberry creek	109	
Polecat creek	58	
Mulberry creek at Callierville	141	
Mulberry creek above Polecat creek	229	
Mulberry creek at mouth	288	
Cotoma creek	383	These may be classed as prairie streams. They lie in the cotton-belt, in a district deficient in springs, and with a flat open surface. With the exception of Pine Barren creek none are reported to be used for power, and they are probably not favorable for such use.
Pintlala creek	308	
Big Swamp creek	264	
North branch of Cedar creek	147	
South branch of Cedar creek	235	
Cedar creek at mouth	497	
Bogue Chitte at Martin's	259	
Bogue Chitte at mouth	377	
Chilatchee creek	140	
Pine Barren creek at Selma and Gulf Railroad crossing	236	
Pine Barren creek at mouth	360	
Dickinson's creek	55	
Turkey creek	245	
Parsley creek (including Gravelly creek)	111	Situated in the pine-belt, where the surface is undulating and sandy, and springs abound.
Bear creek (including Duck creek)	59	
Cane creek	43	
Silver creek	30	
Flat creek	315	
Limestone creek	194	
Pigeon creek	45	
Lovet's creek	108	
Little river	153	
Major's creek	46	

THE CAHABA RIVER.

The source of the Cahaba river is near the boundary between Saint Clair and Jefferson counties, Alabama, 90 miles north of Montgomery. The stream takes a southwesterly and then southerly direction, passing through portions of the counties of Saint Clair, Jefferson, Shelby, Bibb, Perry, and Dallas, and joins the Alabama river 15 or 20 miles below Selma. In former years the river was navigable for 88 miles from its mouth, to Centreville, which is now looked upon as the head of navigation, although in over 30 years no steamer has ascended to that point. This portion of the river was surveyed in 1874, and the 24 miles up stream from Centreville, to Shades creek, in 1880. From the report of Mr. C. B. Percy, United States assistant engineer, upon this latter survey,(*a*) most of the information here presented is drawn. As a result of these surveys it was estimated that a 3-foot channel could be secured from the mouth to Centreville at a cost of $195,000, and that the improvement could be extended by locks and dams to the northern boundary of Bibb county at an additional expense of $381,000.

The Cahaba has a length of about 115 miles, measured in the general direction of its flow, and a drainage area of 1,950 square miles. There are no places of importance directly upon its course. Cahaba, at the mouth, was once the state capital, but is now a little village of 100 or 200 inhabitants. Centreville has a population of about 300, and Marion, 4 miles west of the river, in Perry county, 2,100. A few miles from the river in its upper course is Birmingham, an important mining town. Although a considerable portion of the Cahaba valley is sparsely settled, the resources of the country tributary to the river are of great value. In Dallas, Perry, and Bibb counties the cotton production is large, being estimated at 50,000 bales annually. Farther up the river are magnificent deposits of iron and coal, the former especially noticeable along the Little Cahaba, where is found brown hematite ore in inexhaustible quantities, fuel and flux also lying close at hand.

In Berney's *Hand-book of Alabama* (1878) the following account is given of the fine deposits in the vicinity of Birmingham: "About 1 mile to the southeast of the corporation lies Red mountain, said to be, both as to quantity and accessibility, the most remarkable deposit of iron ore yet known. It extends in a northeasterly and southwesterly direction, parallel with the Alabama Great Southern railroad, for about 30 miles below and the same distance above the city, attaining its maximum depth of ore opposite the latter place, where it contains several seams of ore averaging nearly 50 per cent. of metal and aggregating about 25 feet of vertical depth. The ores

a See Appendix K, *Report of Chief of Engineeers*, 1881.

are red and brown fossiliferous. Besides these there are magnetic and black-band ores within reach and of easy access. On either side of Jones' valley, in which Birmingham is located, and which is here about 5 miles in width, lie to the southeast and northwest, respectively, the Cahaba and the Warrior coal-fields, both of which are traversed by the South and North Alabama railroad. A dozen or more mines are operated near Birmingham, along the latter road, to say nothing of others off the railroads, which are worked in a rather primitive way, the coal being hauled in wagons to market."

Marble suited to building-purposes is found along the stream within 10 miles of Centreville, and over all the upper basin there is a splendid growth of pine timber.

At present the only use of water-power on the Cahaba is by a few saw- and grist-mills in the extreme upper waters. Above Centreville there are reported to be good opportunities for developing power; the bed and banks are favorable, the volume is tolerably well sustained, the current is swift, and interrupted by numerous ripples and rapids. The stream is at the disadvantage, however, of having poor railroad facilities; its lower course is crossed by the Alabama Central railroad, and its upper portion by the South and North Alabama, but the intervening section is without convenient means of access. The country above Centreville is rugged, but with fine lands and excellent timber. For about 10 miles above the point mentioned the river is described by Mr. Percy as averaging 200 feet in width. The bed is rock, covered here and there with gravel and sand. The surrounding country shows considerable settlement and cultivation, which disappear in the main from the neighborhood of the river above. For the next 5 miles the rise averages nearly 11 feet per mile (53.8 feet of rise in 4.91 miles); the bed is rock, covered with bowlders, and the stream is more turbulent than below, with long shoals and frequent falls. The banks rise steep and high on both sides, and the adjacent country is heavily clothed with pine.

From Shades creek down to Centreville, 23.67 miles, the fall is 121.4 feet, or an average of 5.13 feet per mile; thence to the mouth, 88 miles, the fall is 127.4 feet, equal to 1.45 foot per mile. During Mr. Percy's survey the discharge of the stream was determined at two points, but the measurements seem to have been made at a stage considerably above low water, and are not therefore of much value for the purposes of this work. There are no records showing with accuracy the rainfall on the Cahaba basin, but at Greensborough, a little to the west, the average of twelve years is 13 inches in spring, 12 in summer, 10 in autumn, 16 in winter, and 51 for the year. Concerning that part of the river above Shades creek no information has been secured, but thence to Centreville there are several shoals of importance, the fall on which, as revealed by the government survey, is given in the following table, together with a rough estimate of the available power:

Estimate of power at the principal shoals on the Cahaba river, from Shades creek to Centreville.

Name of shoal.	Drainage area.	Rainfall on basin. (b)					Length of shoal.	Fall on shoal.	Theoretical horse-power. (c)		
		Spring.	Summer.	Autumn.	Winter.	Year.			Low water, dry year.	Low water, average year.	Available 10 months, average year.
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*			
Half-Mile rapids	570						2,050	8.4	80	110	150
Long Island rapids	....						1,820	12.2	110	150	220
Lily shoals	....	13	12	10	16	51	3,800	8.9	80	120	170
Bailey Reach rapids	....						2,300	14.5	150	210	300
Big shoals	a 660						5,050	22.3	230	330	480
Centreville shoals	1,080						5,000	8.4	130	190	290

a Above Little Cahaba river. b Record for twelve years at Greensborough. c Based on the average flow for the twenty-four hours.

Drainage areas of the Cahaba river and tributaries.

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
East Cahaba river	48	Blue Gut creek	39
West Cahaba river	163	Legroon creek	40
Shades creek	140	Ockmulgee creek	251
Little Cahaba river	292	Cahaba river at junction of East and West forks	211
Hill's creek	75	Cahaba river at South and North Alabama Railroad crossing	331
Sandy creek	35	Cahaba river below Shades creek	563
Haysoppy creek	65	Cahaba river at mouth	1,950
Affiance creek	43		

THE TALLAPOOSA RIVER.

The main branch of this river rises in Paulding county, in northwestern Georgia; it flows through that and Haralson counties into Alabama, and then continues in an irregular southwesterly direction, until it unites with the Coosa to form the Alabama river. The main portion of its course lies in the region of metamorphic rocks, but at Tallassee, 50 miles from its mouth, it leaves these and, descending a series of beautiful falls and rapids, enters

upon the Cretaceous formation. The area drained by the Tallapoosa comprises 4,935 square miles, of which about 700 are in Georgia. This region is distinguished in the main by a healthful climate and by the possession of valuable mineral and agricultural resources. The portion south of the latitude of Tallassee is in the cotton-belt; it is cultivated successfully for wheat, rye, oats, and a variety of other crops, but the great and staple productions are cotton and corn. To the northward the soil is reddish or gray, with clay subsoil, and is especially suited to the raising of grain, fruits, and vegetables, though cotton can be grown to advantage. The granite and gneiss of this section afford good building-material, and the gneiss has been used for the Tallassee cotton factory. Soapstone, asbestos, mica, and corundum are found. Gold is profitably obtained from the gravels and sands at Arbacoochee, in Cleburne county, and at other points; copper occurs in the same county. There are extensive beds of iron pyrites in Clay county, and in Randolph and Chambers counties are met considerable quantities of magnetite. A limited settlement and poor railroad facilities have prevented any great development of these resources.

The almost entire absence of suitable railroad communication throughout that portion of the river having value for power is, of course, a hinderance to its immediate use for that purpose, but will be remedied as the country grows and new lines are built. The Savannah and Memphis railroad runs northwesterly from Opelika and crosses the river in Tallapoosa county, but the main stream is not accessible by railroad at any other point above Tallassee; below there, most of the way to the mouth, it is followed at a moderate distance by the Western Alabama railroad.

By map measurement the main Tallapoosa has an extreme length of about 225 miles. For nearly 50 miles from the mouth it is susceptible of being made navigable at a moderate outlay. In 1880 a survey was made as far as the Tallassee falls by Mr. Gavin B. Yuille, United States assistant engineer; (*a*) upon this were based estimates that a low-water channel of 3 feet depth and 60 feet width could be secured for 48 miles from the mouth, to the foot of the Tallassee reefs, for $40,000, and that at a total cost of $275,000 the channel could be made 80 feet wide, 4 feet deep, and extended to the foot of the Great falls, 2 miles above.

At the time of this survey the discharge of the river was gauged at Fort Decatur bluffs, 41 miles from the mouth, and found to be 1,420 cubic feet per second; the stage of the river was considered to be mean low water. The drainage area above this point being 4,040 square miles, the above discharge corresponds to 0.35 cubic foot per second per square mile.

The only important place directly on the main river is Tallassee, the town containing about 1,200 inhabitants. Dadeville, county-seat of Tallapoosa county, is distant a few miles from its course, and has a population of 700, and Carrollton, Georgia, near the head-waters of the Little Tallapoosa, 900. The main portion of the district drained by the Tallapoosa is elevated and quite hilly, heavily timbered with oak and yellow pine. In Paulding and Haralson counties, Georgia, the upper waters are used for power by a few small grist- and saw-mills, but the only important manufacturing place on the whole stream is at the Tallassee falls, 65 or 70 miles by river from Montgomery and about 400 miles from Mobile. Here the river, which above is a rough and rapid stream, spreads out to a width of a quarter of a mile or more and incloses several islands, some of them of considerable extent. Through the "sloughs" thus formed it has a rocky bed more or less overlaid by gravel. As it approaches the falls it narrows, and through two or three principal channels pours down a foaming torrent, descending 52 feet in about 300 feet. Immediately below the Great falls it decreases in width to from 200 to 400 feet and then passes on through a deep pool with an average breadth of from 400 to 600 feet. The pool is a quarter of a mile long, and is succeeded by rough water, which continues at intervals for perhaps a mile and a half down stream. In this distance the bed appears to be mainly of solid rock, with many bowlders; the stream pitches over numerous low ledges, and falls 10 feet at one point. In the 1½ or 2 miles from the foot of the Great falls to the lower end of the rapids there is a total descent of 32 feet, below which quiet water continues. All along this section the immediate banks are abrupt and high, rising probably from 25 to 50 feet above low water. Near the falls they are very rocky, while at other points they appear to be of loam, gravel, or sand. They are wooded with pine, oak, and other timber, and from their summits the country stretches out, almost a dead level, largely covered with pine woods, but broken here and there by extensive patches of cultivated ground devoted to the raising of corn and other grains.

At the Great falls the river descends, as has been said, through several sloughs or channels. Huge masses of weather-worn rock form a sort of natural dam, almost closing the course; they are composed of gneiss, the strata dipping about 25 degrees to the northward. It is supposed that this natural dam was at some time continuous across the river, but having become honeycombed with pot-holes, many of which are to be seen, either entire in the unbroken portion of the rock or in half-section on the side-walls of the channels, portions of it gave way and left openings for the water as at present.

In 1845 two South Carolina planters started a cotton-mill at this place. They erected a low building, which is still used, and in which fire-arms were manufactured during the civil war. In 1854 the main building was constructed, 210 by 50 feet in size, with an L of 48 by 50 feet; the structure is of stone and is five stories in height. The site of the mills and the little village is in a vale which puts back on the west side of the river, the ground rising rapidly to an elevated plateau which commands a charming view of the valley below.

The present company is known as the Tallassee Falls Manufacturing Company, and has a capital stock of $400,000. Sheetings, shirtings, duck, cotton rope, and cotton yarn are made, and a ready sale is found for the bulk of the goods at Montgomery. In the spring of 1881 there were run 18,000 spindles, and 500 hands were

a See Appendix K, *Report of Chief of Engineers*, 1881.

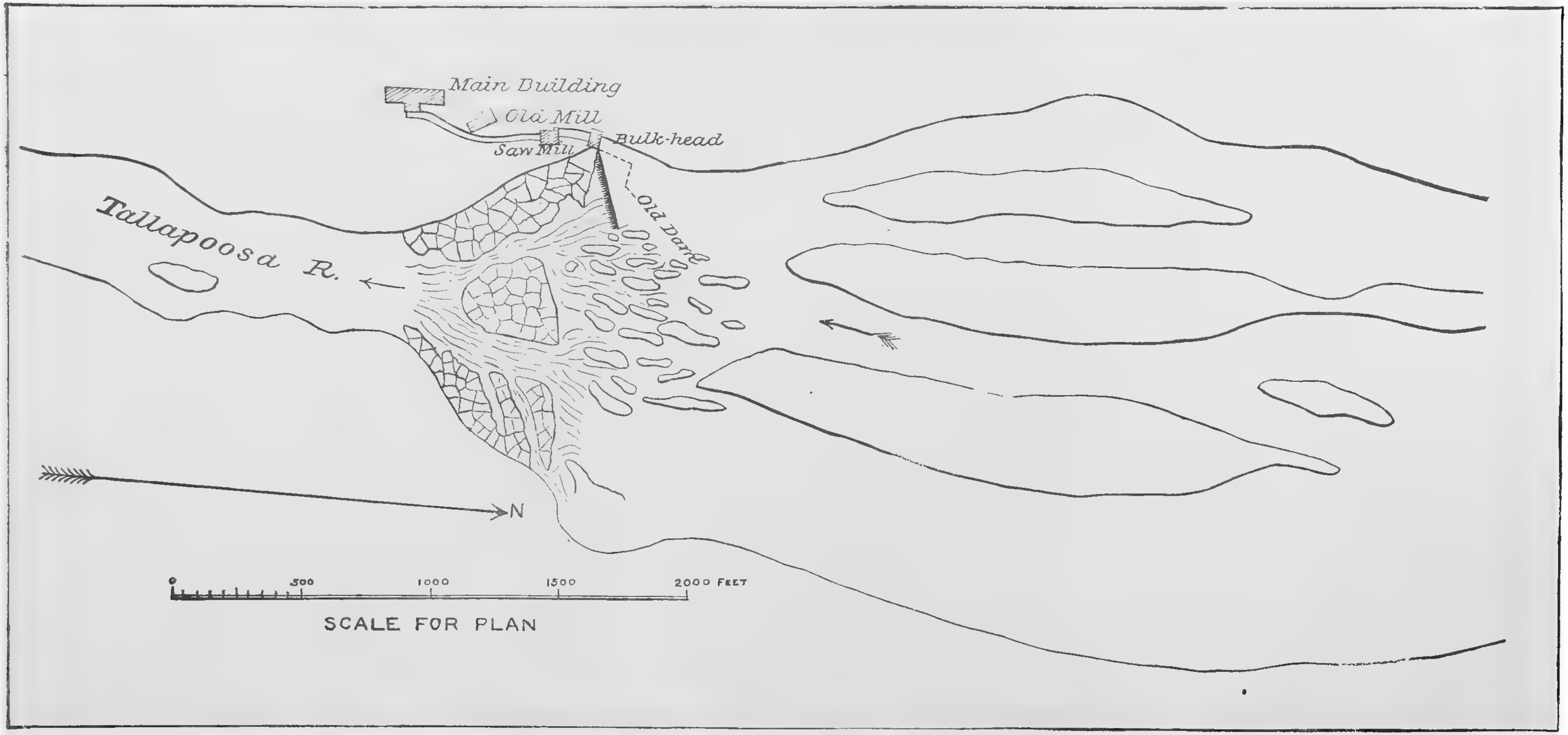

FIG. 1.—Plan of the Tallassee Falls, Tallapoosa river.

FIG. 2.—View of the Tallassee Falls Manufacturing Company's water-privilege.

employed. The latter are nearly all white people from the surrounding native population, who are said to learn quite readily and to do their work well. The officers of the company state that they find labor cheap, employ mainly girls, and are never troubled with strikes. The enterprise is of great advantage to the surrounding country, not only giving employment to many people, but affording a convenient home market for agricultural products. At the time these mills were visited the daily consumption of cotton was 21 bales, and was shortly to be increased to 32 bales. The shipping facilities at this point, however, are not good, there being but one railroad—the Western Alabama—accessible, and in order to reach that, goods have to be carried 6 or 7 miles by team and to be ferried across the river. The establishment of navigation from Montgomery to Tallassee would prove of great value to the manufacturing interest there.

Only a portion of the flow of the river is controlled for power at the falls. One or two old dams, which did not serve their purpose well, remain in the stream just above the present structure, which is simply a wing-dam running from the west shore out to an island. It is built of stone in cement, rests upon solid rock, and is some 300 feet in length; in cross-section it is 9 or 10 feet wide at the base, 6 feet wide at the top, and varies in height above foundation from 6 to 15 feet. An iron strap runs along the coping, and drift-bolts extend down to bed-rock. The dam has a masonry abutment, and water is admitted through a timber bulkhead to the canal. This follows along the side-hill, having a heavy retaining-wall on the river side, and ranges from 15 to 30 feet in width and from 5 to 7 feet in depth.

The extreme fall now in use is 32 feet, which may easily be increased to 40 feet. Uppermost on the line of the canal are a saw-mill and carpenter-shop, using together perhaps 60 horse-power from old scroll wheels. Then follow, in order, an overshot wheel running a pump which supplies the factory and village; a 3-run grist-mill taking power from a 32-foot overshot; and the cotton-mills, where power is used as follows:

	Horse-power.
Old mill, one 40-inch Leffel wheel, 24 feet head, rated at	118
Main mill, one 56-inch Leffel wheel, 24 feet head, rated at	290
Main mill, one 66-inch Leffel wheel, 24 feet head, rated at	433
New mill, one 48-inch Leffel wheel, 32 feet head, rated at	264
Total rated power of 4 wheels	1,105

The superintendent of the factory estimates that about two-thirds of the rated power, or say from 700 to 750 horse-power, is actually in use. Last in order is a foundery and blacksmith-shop, with a small overshot wheel. It is probable that altogether not far from 900 effective horse-power is in use on the privilege, and the surplus volume of the river always represents a large additional power which is wholly unemployed. The Tallasse Falls company owns the land on the west side of the river, both above and below the falls, covering a distance of several miles. It also owns a two-sixths interest in the power on the opposite side of the river at the falls. That site is capable of being developed into a fine privilege, but it is considered that its improvement would be expensive on account of the rock-cutting which would be necessary for a canal.

Below the main falls the principal disadvantage to the development of power lies in the exposure to a somewhat heavy freshet-rise, and consequent trouble from backwater. The Tallapoosa is a stream subject to large, and sometimes extremely sudden, oscillations, brought about by winter and early spring rains. At such times it becomes a turbid and dangerous flood, though commonly a clear and beautiful stream. The rise in this vicinity varies much at different points; at the head of the Great falls it is only 5 or 6 feet, at their foot 14 feet, and for a mile and a half down stream about 20 feet, never reaching the top of the banks, however. Still below, the slope of the river becomes much reduced, freshet-waters are less readily carried off, and the rise is great enough at times to submerge the banks. It is generally considered that for at least a mile below the main falls the water-power can be improved advantageously. With only one record of the discharge, and hardly any data concerning the rainfall on its drainage basin, it is difficult to make a reliable estimate as to the power of the Tallapoosa in this vicinity, nor can it here be stated with accuracy how much fall would be found practically available; but under various assumptions as to the fall it is probable that the powers expressed in the following table could be realized:

Estimate of power at Tallassee falls and vicinity.

Stage of river.	Rainfall on basin.(a)					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.					
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	32 feet fall (extreme fall now in use).	40 feet fall (easily available at cotton factory).	52 feet fall (total at Great falls).	75 feet fall.	84 feet fall (total from head of falls to foot of reefs, probably not all available).
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cu. feet.*						
Low water, dry year							1,140	129.5	4,140	5,180	6,730	9,710	10,880
Low water, average year	14	13½	10½	14½	52½	3,520	1,430	162.4	5,200	6,500	8,440	12,180	13,640
Available 10 months, average year							2,000	227.2	7,270	9,090	11,810	17,040	19,080

a Roughly estimated from Smithsonian records.

Ascending from the Tallassee falls, the river is described as having a generally rough character. It flows with rapid current over a rocky bed, and is frequently crossed by low ledges forming natural dams. The banks are high, rocky, and wooded with pine and other timber. The surrounding country is very hilly, and cultivated only to a limited extent. As previously remarked, there is no manufacturing above Tallassee except by a few saw- and grist-mills, mainly in the extreme upper waters. There can be little question, however, that when the section drained by the Tallapoosa shall have become more developed, the splendid water-powers furnished by the stream will be made to support extensive industries.

The main river receives numerous tributary streams which are used by small saw- and grist-mills, and which are said to offer many fine opportunities for manufacturing. The Songahatchee, emptying from the east a few miles above Tallassee, was especially referred to as a good representative of these tributaries, which have generally rocky or gravelly beds, high banks, and a very steady discharge.

Estimate of power of the Tallapoosa river at different points in its course.

Locality.	Rainfall on basin.(a)					Drainage area.	Theoretical horse-power per foot of fall.(b)		
	Spring.	Summer.	Autumn.	Winter.	Year.		Low water, dry year.	Low water, average year.	Available 10 months, average year.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*			
Tallapoosa, Haralson county, Georgia	14	12	10	15	51	205	5.7	9.1	13.6
Below Ketchepedrakee creek	14	12	10	15	51	725	22.7	34.1	47.7
Below Little Tallapoosa river	14	12	10	15	51	1,470	51.1	70.4	98.8
Below Hillabee Hatchee creek	14	12½	10	15	51½	2,570	97.7	122.7	170.4
Below Kiolijah creek	14	13½	10½	14½	52½	3,177	119.3	150.0	209.0
Tallassee falls	14	13½	10½	14½	52½	3,520	129.5	162.4	227.2

a Roughly estimated. *b* Based on the average flow for the 24 hours.

Principal tributaries of the Tallapoosa river (in order from its source).

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Cane creek	65	Elkehatchee creek	72
Ketchepedrakee creek	56	Sandy creek at Dadeville	49
Mad Indian creek	36	Sandy creek at mouth	120
Little Tallapoosa river at Carrollton	75	Blue creek at Savannah and Memphis Railroad crossing	86
Little Tallapoosa river at state line	346	Blue creek at mouth	176
Little Tallapoosa river below Cat Nese creek	480	Kiolijah creek	131
Little Tallapoosa river at mouth	650	Songahatchee creek north of Notasulga	156
Cat Nese creek (tributary to Little Tallapoosa)	23	Songahatchee creek at mouth	247
Piney creek (tributary to Little Tallapoosa)	26	Arapa creek at Chehaw	361
Wedowee (?) creek (tributary to Little Tallapoosa)	49	Arapa creek at mouth	452
Fox creek	50	Wallahatchee creek	32
Crooked creek	82	Tomgahatchee creek	46
Chillisado creek	99	Caleebee creek(*a*)	158
Cohensanersa creek	69	Cupia Hatchee creek (*a*)	127
Hoolethloceo creek	124	Oakfuskee creek (*a*)	333
Hillabee Hatchee creek at junction of East and West forks	167	Hatchee Chubbee creek	72
Hillabee Hatchee creek at mouth	287		

a Lie in the cotton-belt, and are not used for power.

THE COOSA RIVER.

This river, the most important tributary of the Alabama, is formed at Rome, in northwestern Georgia, by the union of the Etowah and Oostenaula rivers. It passes westerly across Floyd county, and entering Alabama pursues a southwesterly and then southerly direction, till it joins the Tallapoosa a few miles below Wetumpka. In its passage through Alabama it either runs across or borders the counties of Cherokee, Etowah, Saint Clair, Calhoun, Talladega, Shelby, Chilton, Coosa, and Elmore. Although, measured along its general course, this river is only about 165 miles long, yet its actual length, following the many windings, is not far from 335 miles.

As described by Professor Tuomey, the Coosa, from its source to Greensport, Saint Clair county, runs along the strike of the rocks, following a valley between the strata. It then turns more to the southward and crosses the edges of the strata, forming rapids where the rock is hard and indestructible, alternating with quiet pools where the softer limestone is met. The lower course, from the latitude of Shelbyville to Wetumpka, is along the inner edge of the region of metamorphic rocks. These, with the accompanying rapids, are left at Wetumpka,

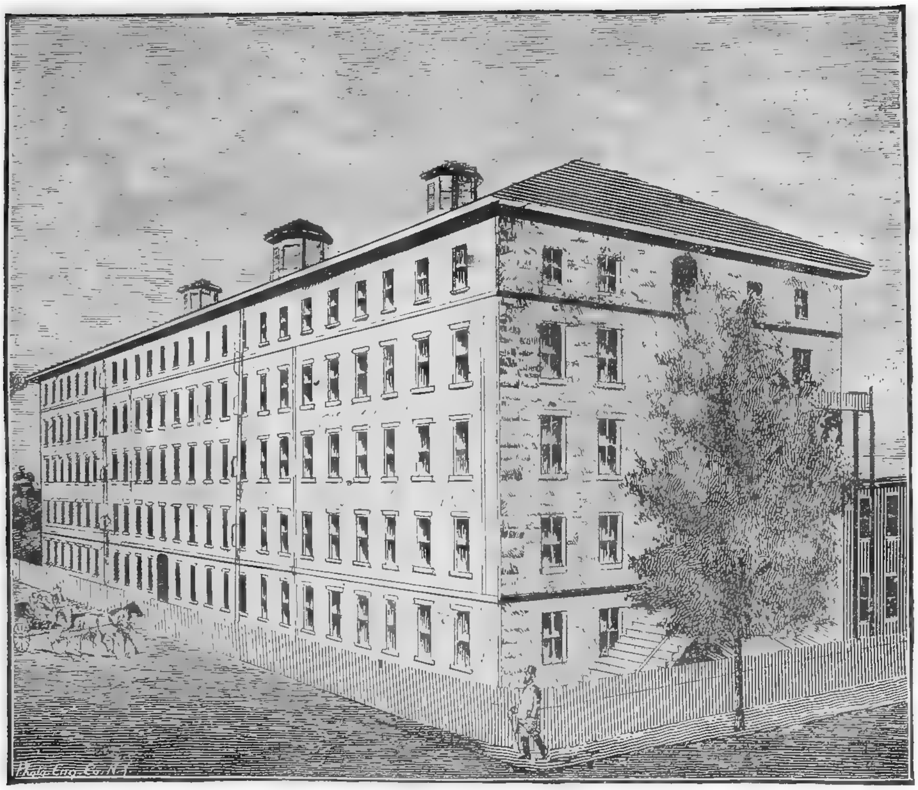

FIG. 3.—Tallesse Falls Manufacturing Company's mill.

and for the remaining short distance to the mouth there is deep and quiet water. The Coosa thus comes to present the unusual condition of a stream navigable at its head and foot, but for a long intervening distance filled with impassable rapids. From the mouth navigation is shut off by the falls at Wetumpka, but from Greensport for about 180 miles to Rome it is practicable and is availed of; half a dozen steamers ply over this portion for nine months in the year, and three of them throughout the year. A great deal of lumbering is done along the stream, and large amounts of timber are towed to Gadsden in rafts, transferred to the railroad, and shipped north.

With a view to the improvement of the 145 miles, more or less, of river between Wetumpka and Greensport, several surveys have been made by the general government. If navigation could be secured over this stretch, then it would extend uninterrupted for about 800 miles from Mobile to northwestern Georgia and the southern boundary of Tennessee. In order to bring about this desirable result a series of locks and dams must be built, the expense of the improvement from Wetumpka to the Selma, Rome, and Dalton Railroad crossing being estimated at $2,650,000,(*a*) and for the remaining portion above at $550,000,(*b*) or about $3,200,000 for the entire distance. Up to the spring of 1881 the work actually undertaken had been confined to a stretch of about 35 miles below Greensport. The improvement of this section, under charge of Major W. R. King, Corps of Engineers, comprises the construction of three dams and accompanying locks, one of the former reaching across the river, 1,100 feet, a second closing a chute, and a third extending 2,000 feet up stream as a wing-dam.(*c*) The completion of another dam, at what are known as the Broken Arrow shoals, is to give navigable water to the coal-fields of Saint Clair county. Up to March, 1881, inclusive, $285,000 had been appropriated to this part of the Coosa river.

Drainage areas.

	Square miles.
Etowah river	1,940
Oostenaula river	2,190
Coosa river below junction of Etowah and Oostenaula rivers	4,130
Coosa river at mouth	10,610

The section of country lying within the Coosa basin has rich resources which are as yet scarcely touched. Bituminous coal, iron, and limestone abound, often in close proximity. The Coosa coal-field is one of the three great coal-fields of Alabama, and along its southeastern border extends what is described by Prof. E. A. Smith as the "wide limestone valley" of the river we are studying. As stated in Berney's *Hand-book of Alabama*, the main deposits of brown hematite ore in the state lie along the course of the Selma, Rome, and Dalton railroad (*d*) from Brierfield across and to the east of the river, and along the line of the Alabama Great Southern railroad to the westward of the river; while, stretching to the northeast from Tuscaloosa through Birmingham and into Georgia, there is a wonderful mass of red hematite, the Red Mountain deposit of which has already been described in speaking of the Cahaba river. The principal iron mining in the Coosa basin in Alabama is at Shelbyville, in Shelby county, and at various points in Cherokee county. Several other minerals are found in this section, including gold, copper, lead, plumbago, and manganese. Slate of fine quality, pottery and fire-brick clay, and soapstone occur, while the limestone, granite, and gneiss afford excellent building-materials. There are extensive forests of pine, oak, and other varieties of timber. The agricultural resources are also valuable, the soil in the lower basin being best adapted to cotton, and in the upper portion to grain. The most important points along the river are Wetumpka, some 10 miles from the mouth, with a population of 800; Gadsden, in Etowah county, with 1,700; and Rome, Georgia, with 3,900.

From what has been said it may be seen that the only portion of the river to be considered with reference to water-power is that lying between Greensport and Wetumpka, covering in the neighborhood of 145 miles. So far as can be learned there is at present no power used in this distance except by a small flouring- and grist-mill in Saint Clair county, obtaining a fall of $3\frac{1}{2}$ feet, probably by a wing-dam. In the report by Major Walter McFarland, Corps of Engineers, U. S. army, embodied in the *Chief of Engineers' Report for* 1872, the fall from Greensport to Wetumpka is stated as 360 feet; and the total fall upon rapids between the Selma, Rome, and Dalton Railroad crossing and Wetumpka as 260 feet. The superintendent of the East Tennessee, Virginia, and Georgia railroad gives the elevation at its Rome crossing, at the head of the Coosa, as 652 feet above tide.

Although from lack of time the river was not personally examined, it is judged from government engineers' descriptions of it that at many points on the rapids power might be developed to advantage; and since it contains numerous long islands forming chutes between themselves and the adjacent banks, it is not improbable that at such points, as is the case on the Chattahoochee river, good powers might be obtained at slight expense. The width of the river is large on the shoals, ranging from 650 to 2,000 feet above the Selma, Rome, and Dalton Railroad crossing, and from 1,000 to 3,000 feet on the section below. The control of the entire flow of the stream would therefore in many cases involve heavy expense for a dam, and certainly no such enterprise would be undertaken without having regard to the possible improvement of the entire river by the United States government.

a Senate Ex. Doc. No. 42, *Forty-sixth Congress, third session.*
b See *Report of Chief of Engineers, U. S. army*, 1881, p. 1873.
c See Appendix X 9, *Report of Chief of Engineers*, 1881.
d Alabama division of the East Tennessee, Virginia, and Georgia railroad.

As has been said, the design is to extend the system of locks and dams so as ultimately to overcome all the rapids by slack-water navigation. If that design should be carried out, the surplus water at the dams above the requirements of lockage would probably be available, under proper restrictions, for power; and the opinion is expressed by those engineers having charge of the river, that favorable sites for manufacturing would undoubtedly thus be created.

Probably the principal disadvantage that would be experienced in the actual use of power would be an occasional hinderance from backwater during freshets, which are sometimes very heavy and sudden. Regarding the rises in the river, Mr. Gavin B. Yuille, United States assistant engineer, in his report upon a survey of the 68½ miles above Wetumpka,(*a*) remarks as follows:

The oscillation of the river-surface during freshets was found to be very variable, being governed by width and inclination of the channel. On the shoals where the river-channel is from 1,000 to 3,000 feet wide and there is an inclination of 10 or 12 feet in a mile, the oscillation ranges from 6 to 8 feet, while at Wetumpka, where the river has a width of 700 feet between high banks, and situated at the head of slack-water river below, we find an extreme oscillation of 53.71 feet, and at all points where the river is of contracted width and deep slack-water channel the oscillation is from 20 to 40 feet.

On the section of river below and adjacent to Greensport, where a system of locks and dams is being completed, the most favorable sites for power are mentioned as being Whistenant's Mill shoals, where there is a fall of 5½ feet available; Ten-Island shoals, where the fall is 12 feet in a mile and a quarter; and Broken Arrow shoals, where it is designed to erect a dam 12 feet high.

The upper Coosa is bordered by a considerable amount of bottom-land, beyond which rise high hills well wooded with pine. The lower valley is more contracted, and shows only occasional narrow strips of bottom-land, subject to overflow during extremely high freshets; in this section, where the banks are not of the character described they are usually high and rocky, and even at times precipitous. The channel shows "a succession of confined level pools of deep water, connected by sloping reaches of broad and shallow reefs and shoals, filled with numerous islands and rocks, with narrow and shoal runs of water between". The pools are very deep, sometimes from 40 to 60 feet, and the river-bed is almost entirely of bare solid rock, with scarcely any deposit covering it.

Undoubtedly the finest power to be obtained on the Coosa river is at Wetumpka, within 10 miles or so of the mouth. Ascending from the city, a succession of shoals and pools, ranging usually from 4,000 to 6,000 feet each in length, is encountered, after which there is a continuous shoal stretching 7 miles up stream. The river-banks in the section below are high and rocky. The head of the shoals mentioned is at a distance of nearly 15 miles by river above the Wetumpka bridge, and is said to offer a favorable site for a dam. By bringing a canal from that point down the east bank to Wetumpka, security from the reach of high water would be obtained, and a fall made available at the city of not far from 80 feet in the most favorable stage of river. During freshets this fall would be liable to be reduced one-half, and even more in extreme cases. The expense of constructing a canal of proper capacity 12 or 15 miles in length, even if the cost of a dam could be avoided by taking advantage of one erected by the government in case of the improvement of the stream for navigation, would be very great—sufficiently so, perhaps, to forbid the undertaking. The power to be obtained, however, would be magnificent, and calculated to build up an important manufacturing city.

Estimate of power available at Wetumpka.

Stage of river.	RAINFALL ON BASIN. (*a*)					Drainage area.	Flow per second, average for the 24 hours. (*c*)	Theoretical horse-power.			
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	40 *feet fall.*	60 *feet fall.*	80 *feet fall.*
Low water, dry year							2,130	242.0	9,680	14,520	19,360
Low water, average year	14½	14	10	15½	54	*b* 10,235	2,560	290.8	11,630	17,450	23,260
Available 10 months, average year							3,560	404.4	16,180	24,260	32,350

a Roughly estimated.

b At a point 15 miles by river above Wetumpka.

c In case of the improvement of the stream by locks and dams for navigation, Mr. Yuille estimates the demand for lockage at an average of 56 cubic feet per second, assuming a lock 210 × 40 × 8 feet to be emptied once in 20 minutes throughout the day; and estimates the total loss by lockage and waste at 124 cubic feet per second, which is neglected in the above table.

Notwithstanding the large amount of undeveloped power presented by the Coosa, the limited extent to which manufacturing is carried on in this section seems to have prevented any special demand for it, and even if manufacturing enterprises were more common many would doubtless avail themselves of the opportunities for obtaining coal cheaply and would use steam-power. For establishments to be located directly upon the main river railroad facilities are poor. About midway between Greensport and Wetumpka is the crossing of the Selma, Rome, and Dalton line; but, except in that vicinity, the course of the river between the two points mentioned is distant from 5 to 15 miles from the nearest railroad.

a Senate Ex. Doc. No. 42, *Forty-sixth Congress, third session.*

Estimate of power at the principal shoals on the Coosa river (in order below Greensport[a]).

Name of shoal.	Drainage area (approximate).	Length of shoal.	Fall on shoal.	Theoretical horse-power.(b) Low water, dry year.	Low water, average year.	Available 10 months, average year.	Remarks.
	Sq. miles.	*Miles.*	*Feet.*				
Whistenant's Mill shoals	6,870	....	5.50	1,020	1,220	1,710	Immediately below Greensport; 5½ feet is the fall said to be available for power.
Ten-Island shoals	....	1.40±	12.00	2,370	2,850	3,950	Eighteen or twenty miles below Greensport; 12 feet is the fall said to be available for power.
Broken Arrow shoals	7,320	1.70±	12.00±	2,370	2,850	3,950	Forty-eight miles above the Selma, Rome, and Dalton Railroad crossing. To be improved for navigation by a dam with lock of 12 feet lift.
Chocholoco shoals	....	1.30±	5.00	990	1,190	1,650	Thirty-eight miles from the Selma, Rome, and Dalton Railroad crossing. Shoals occur between an island and the mainland, the west channel being 1,200 and the east 150 feet wide.
Claunche's shoals	....	0.06	12.00	2,520	3,010	4,200	One-half mile above Claunche's ferry. Shoals caused by a reef of rock.
Drake's Mill shoals	....	0.95±	7.00	1,470	1,760	2,450	Reef of rock crosses river midway of shoal.
Turner's Mill shoals	8,020	0.38	4.00	840	1,000	1,400	River 800 feet wide at head of shoals.
Shoals down stream from head of Weduska shoals.	9,130	7.30+	55.75	12,350	14,820	20,580	Weduska shoals begin about 18 miles below the Selma, Rome, and Dalton Railroad crossing. Thence down stream the river is described as "one mass of shoals, rapids, reefs, filled with rocks, islands, and willows growing in the water, and varying in width from 1,000 to 1,800 feet".
Tuck-a-league shoals	9,420	5.25	39.00	8,990	10,760	14,980	Head of shoals about 32 miles below the Selma, Rome, and Dalton Railroad crossing.
Duncan's ripple	10,050	0.66	8.38	2,000	2,400	3,330	Channel width, from 700 to 1,200 feet.
Fish-Trap reef	....	0.57	10.00±	2,400	2,870	4,000	Dam proposed with lock of 10 feet lift; river about 1,600 feet wide, and runs swiftly over rocky reefs.
Hell's Gap reef	....	....	10.00±	2,400	2,880	4,010	Dam proposed with lock of 10 feet lift.
Reef below Huffman's ferry	....	....	9.00±	2,170	2,600	3,620	Dam proposed with lock of 9 feet lift.
Welonee Creek reef	....	....	9.00±	2,170	2,610	3,630	Do.
Reef 1½ mile below Grey's ferry	10,235	....	8.00±	1,940	2,330	3,230	Dam proposed with lock of 8 feet lift.
Staircase falls	....	0.49	8.00	1,950	2,340	3,260	River widens to 3,600 feet, is very shoal, and is filled with reefs and masses of rock.
Staircase falls (lower)	....	0.57	8.00	1,960	2,350	3,270	
Reef above Closet reef	....	....	8.00±	1,960	2,350	3,270	Dam proposed with lock of 8 feet lift.
Closet reef	....	....	8.00±	1,960	2,350	3,270	Do.
Sofkahatchee reef	....	....	8.00±	1,960	2,360	3,280	Do.
Grey's Island shoals	....	....	8.00±	1,960	2,360	3,280	Do.
Rose's reef	....	0.26	4.14	1,020	1,220	1,700	
Corn Creek reef	....	0.95	7.63	1,880	2,250	3,130	
Wetumpka rapids	....	0.76	12.60	3,120	3,740	5,180	
Total for above shoals, with falls as assumed.	....	....	277.00±	61,600	73,870	102,710	The only utilization of power reported is made by a single small grist-mill.
Total power assumed to be available at Wetumpka by canal from first reef below Grey's ferry, a distance of nearly 15 miles.	....	15.00±	80.00	19,360	23,260	32,350	

a Data concerning shoals are taken from report by G. B. Yuille (*Senate Ex. Doc. No. 42, Forty-sixth Congress, third session*), and from report of James C. Long (*Report of Chief of Engineers*, 1872). The table is intended to show approximately the power corresponding to the natural fall, in the main, on various shoals; the fall practically available at the different localities would doubtless vary much from the figures here employed, being governed by the height of dam and length of canal. The real value of the shoals for manufacturing use is to be determined only by careful examination.

b Based upon average flow for the 24 hours. With good wheels, from 60 to 80 per cent. of the theoretical power can be realized.

NOTE.—The rainfall on the basin may be taken roughly at 14½ inches in spring, 14 in summer, 10 in autumn, 15½ in winter, and 54 for the year.

TRIBUTARIES OF THE COOSA RIVER.—Below the point of its formation by the Etowah and Oostenaula rivers the Coosa receives many minor tributaries, ranging in size of drainage area from about 500 square miles downward, and to which the same general remarks would apply as to the corresponding tributaries of the Tallapoosa, which have elsewhere been spoken of. Two of these were visited—the Chattooga river and Cedar creek, streams of medium size—and a description of them may serve to give an idea as to the capabilities of the rest.

The Chattooga river rises 35 miles northerly from Rome, in northwestern Georgia. From its source in Walker county it runs southwesterly across Chattooga county, into Alabama, joining the Coosa a short distance beyond the state boundary, in Cherokee county. It drains the valley lying between Pigeon mountain, a spur of the Lookout Mountain range, on the west, and Taylor's ridge on the east, and includes within its basin 375 square miles.

This river has the usual characteristics of a mountain stream; it receives its supplies from a rough, hilly, well-wooded section, flows over a rocky bed and between banks that are usually high and rocky, though now and then there occur stretches of productive bottom-land. It is subject to high freshets, with rapid rise and fall. Good sites for power abound, and are generally improved by framed dams, and occupied by small saw-mills, grist-mills, and cotton-gins. The Tryon factory, distant some 25 miles by carriage-road from Rome and 15 miles from any railroad, is the only important manufacturing establishment on the stream. The mill is a fine structure of brick, and is surrounded by a small village, where dwell the operatives, numbering 250 or more. The Tryon Manufacturing Company has a capital stock of $225,000, and runs 9,000 spindles and 258 looms in the manufacture of sheetings,

shirtings, and drills, using 14 or 15 bales of cotton per day. At this locality the Chattooga river is 75 or 100 feet wide, has a rapid current, and its waters are colored a greenish hue by the presence of lime. The site was a favorable one for improvement; where the dam is situated one bank rises abruptly from the stream, rocky and very high, while the other, composed of gravel and having a gentle slope, afforded a convenient course for the canal. The present dam was built in 1877, at a cost of from $1,200 to $1,500, and replaced one which, owing to faulty construction, had been carried out in high water. It is a framed structure, about 250 feet long and 12 feet high, resting on a bed of solid rock. One abutment is a natural ledge, and the other a timber crib-work filled with stone ballast. The back-slope is longer than it was in the old dam, and the space underneath is filled in with loose rock, the omission of which, and a too abrupt slope, are thought to have been responsible for the failure of the first structure. The dam sets back the river for about 2½ miles. A canal perhaps 1,500 feet long and 30 feet wide runs to the factory, and on the way supplies power to a small saw-mill, 3 cotton-gins, and a 2-run grist-mill. At the cotton factory the fall is 16 feet; three Risdon turbines, with an aggregate of 300 rated horse-power, are employed, and about 250 horse-power is estimated to be actually in use. For four months in the year the supply of water runs short, and steam-power has then to be resorted to in part. The drainage area of the river above the Tryon factory is 160 square miles.

Cedar creek empties into the Coosa from the south a few miles above the Chattooga river, and drains an area of 225 square miles lying in Polk and Floyd counties, Georgia. It is a short mountain stream, with a length of only 22 miles, and at Cedartown, at which point its drainage area amounts to 80 square miles, averages about 70 feet in width and 4 feet in depth, and has a good current. Like the Chattooga, it is very rapid in rise and fall. But a short time before it was visited, in the spring of 1881, it had risen, overflowed its banks, damaged the hydraulic canal at Cedartown, and receded within its channel again, all in the space of twelve hours. During the same season the city of Rome was partially inundated by high water from the Etowah and Oostenaula rivers, at the junction of which it is situated. Northwestern Georgia is an elevated region, having an estimated average altitude of 750 feet above the sea. It is frequently visited by very heavy rains in winter and spring, and most of the streams are liable at such times to overflow their banks extensively in those portions of their courses where they are not kept within bounds by high banks or a large slope.

Cedar creek falls quite rapidly, is tolerably well sustained in the dry season, and offers good unimproved sites for power. It is also considerably used by small mills, but the only manufacturing of importance is at Cedartown, where are the extensive works of the Cherokee Iron and Railroad Company. This company was started in 1872, and has now made an investment of over $600,000 at Cedartown and vicinity. It owns a very large tract of land, and is also proprietor of a 3-foot narrow-gauge railroad running 35 miles to Cartersville, said to be very profitable from the outside business obtained, as well as a great convenience to the company, since at Cartersville it is brought into connection with the Western and Atlantic railroad. The narrow-gauge road passes close by one of the company's ore-beds and extends 5 miles to another. The Cherokee company manufactures pig-iron for market, and also makes the rolling-stock for its railroad. In its furnaces it had produced, previously to the spring of 1881, 22 tons of pig-iron per day, under a pressure of from 1¾ to 2 pounds per square inch, and the capacity was then increased to 35 tons, under a pressure of from 4 to 4½ pounds.

A fall of 4 feet, obtained by a dam across Cedar creek, is utilized for power at the company's shops. The dam is substantially built of limestone laid in hydraulic cement. It is about 70 feet long, 10 feet high, and 5 feet thick both at base and top; it was constructed in 1873 at a cost of $5,300. Water is conveyed from above the dam in a canal 500 or 600 feet long, and supplies two water-wheels, yielding together about 70 horse-power; this is used in a 3-run grist-mill, blacksmith-shop, wood-working shop, machine-shop, and foundery, wire cables being employed to transmit a part of the power from one shop to another. The volume of water is always sufficient to furnish the power required in these works, but in dry weather there is no surplus.

Minor tributaries of the Coosa river (in order below Rome).

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Cedar creek	225	Kelley's creek	200
Spring creek	115	Talladega creek	193
Chattooga river	375	Tallassee Hatchee creek (Talladega county)	168
Little river	310	Yellow Leaf creek (Shelby county)	170
Terrapin creek	276	Hatchet creek at Hanover	196
Ball Play creek	73	Hatchet creek below Pinthlocco creek	381
Big Wills creek	413	Hatchet creek at mouth	521
Canoe creek	281	Pinthlocco creek (tributary of Hatchet creek)	84
Tallassee Hatchee creek (Calhoun county)	217	Weogufka creek (tributary of Hatchet creek)	105
Cane creek	114	Waxahatchee creek	238
Broken Arrow creek	85	Chestnut creek	98
Cheekeleeke creek at Silver run	225	Wewoka creek	92
Cheekeleeke creek below Chehawhaw creek	421	Elmore (?) creek	114
Cheekeleeke creek at mouth	486		

THE ETOWAH (*a*) RIVER.

Rising upon the southern slope of the Blue ridge, in northern Lumpkin county, Georgia, this river pursues a westerly course to the Coosa at Rome, passing in the mean time over portions of the counties of Lumpkin, Dawson, Forsyth, Cherokee, Bartow, and Floyd. The section drained comprises 1,940 square miles, and above Cartersville it is but thinly settled; this upper portion, however, has valuable mineral resources, of which the most important are iron, manganese, and gold. Baryta and kaolin are also found, as well as traces of silver, copper, and plumbago, but there is no coal. The valleys are well stocked with timber, and below Cartersville the main valley, which above is quite narrow except where at intervals a patch of a few hundred acres of bottom-land is found in a bend of the river, widens out and contains fine stretches of extremely productive land, which is largely cultivated in grain and cotton. The railroad facilities are good along the lower river, but in the portion farther up, which is best suited to use for power, the stream is directly accessible by railroad at Canton only, to which point there extends a short road from Marietta, to the southward. There is no navigation on the river. A government survey was made in the summer of 1879 to determine upon the probable expense of establishing a navigable channel; but it was found that an improvement by locks and dams—the only practicable method—would cost $2,277,000 for the 63 miles from Rome to the mouth of Little river, and an adverse report was therefore made, it being considered that a heavy outlay of money was not at all warranted by the business likely to be furnished. (*b*) Above the mouth the largest towns are Kingston and Cartersville, in Bartow county, having respectively about 500 and 2,000 inhabitants, and Canton, in Cherokee county, with a population of 400.

In its lower course the fall of the river averages about 3.7 feet per mile, amounting to 232 feet in the 63 miles below Little river. This descent is not uniform, however, being distributed among reefs and rapids, with short intervening pools. From Cartersville up, the Etowah is quite closely hemmed in by mountains, which rise rapidly from its banks, and which, being thickly covered with pines, except where an occasional precipitous crag shows itself, bare of vegetation, give rise to very picturesque scenery. The water of the stream was once remarkably clear, but cultivation of the soil and washing the hill-sides for gold have given it a generally turbid appearance. The oscillations are very rapid and heavy after rains, owing to the steep drainage slopes, and the full height of a freshet is often reached in a few hours. As reported in the government survey, the highest rises have ranged from 12 feet in the upper course to 28 feet at Rome. The lower bottom-lands toward the mouth are liable to overflow, but in the upper and more rapid portion of its course the river seldom rises at all above its immediate banks.

In a list of gaugings of various of the Georgia streams,(*c*) the discharge of the Etowah at the mouth of Allatoona creek, in Bartow county, is given as 1,308 cubic feet per second in minimum low water, corresponding to 1.08 cubic foot per second for each of the 1,213 square miles of drainage area above that point. This discharge certainly appears too large for the stage mentioned, being more than half as great as the volume assumed, on good authority, for average low water at the mouth of the Coosa, although the drainage area there is nearly nine times as great as at the locality mentioned on the Etowah river. Lieutenant Marshall, Corps of Engineers, U. S. army, in his report upon the survey of the river states that "at low water its discharge is slight".

In Lumpkin county the Dahlonega Gold Mining Company has constructed a ditch 3 feet deep, 3½ feet wide at the bottom, and 30 miles in length, to serve the purposes of hydraulic mining. Water is taken from several small creeks tributary to the upper Etowah, and will supply 5 mines with 25 miner's inches (*d*) each.

The fall of the river is rapid in its upper course, and those familiar with the valley consider that it there presents numerous good sites for power, favorable for development and accessible. Between the point where the public road from Dahlonega to Dawsonville crosses, and Simmons' mill-pond, a distance of some 12 miles by road, there is stated to be a fall of 210 feet. Of this amount only 28 feet is utilized, part by a saw-mill, grist-mill, and tannery combined, and part by a 10-stamp mill of the Dahlonega mine; there are several other points, however, which are available for use. The Franklin mine, in Cherokee county, takes power from the Etowah for a 20-stamp mill, using, it is said, a fall of about 15 feet. A narrow-gauge line to run from Gainesville, on the Atlanta and Charlotte Air Line railroad, to Dahlonega had been surveyed and partly graded in the spring of 1881, and if completed will be of great advantage to the extreme upper part of the river. Efforts were about to be made also for the establishment of a cotton factory in this section, it being claimed that the cheapness of water-power, land, fuel, and rents would permit of more profitable manufacture, even with the expense of shipping by team to and from Gainesville, than at Atlanta. Such an enterprise would be of much value in giving employment to the families of the men engaged at the mines. Farther down stream, at High Tower, in Forsyth county, two mills, one of 10 and one of 20 stamps, were reported to have been projected; but, except at the points mentioned and at an occasional site elsewhere occupied by a small saw-mill or grist-mill, no actual use was found to be made of the power of the river.

a Indian pronunciation, Ē-tō-wäh', meaning in Cherokee "beautiful water".

b See *Report of Chief of Engineers*, 1880.

c See *The State of Georgia*, by Francis Fontaine.

d A miner's inch is said to be taken as the discharge through a 1-inch aperture under a head of 6 inches, or about 17,000 gallons per 24 hours.

The descent of the Etowah for a considerable distance below Little river, as determined by government survey, is shown in the following table:

Table showing the fall in the Etowah river for 41.4 miles below the mouth of Little river.

Locality.	Distance below Little river.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Miles.*	*Feet.*	*Feet.*
Mouth of Little river	0.000			
		9.091	19.0	2.09
Boundary between Cherokee and Bartow counties	9.091			
		1.136	2.5	2.20
Head of Maddox island	10.227			
		1.800	18.5	10.28
Foot of Pugh's island	12.027			
		1.231	22.0	17.87
6,500 feet below Pugh's island	13.258			
		0.624	10.5	16.83
Stamp creek	13.882			
		1.270	27.5	21.65
6,700 feet below Stamp creek	15.152			
		0.946	11.0	11.63
11,700 feet below Stamp creek	16.098			
		1.781	1.5	0.84
Western and Atlantic Railroad bridge	17.879			
		23.541	*a* 67.5	2.87
Reynolds' ford	41.420			

a Fall quite uniformly distributed.

It will be noticed that from the boundary between Cherokee and Bartow counties down to the Western and Atlantic Railroad crossing there is a heavy fall, amounting to 92 feet in 7 miles of the distance. This portion of the stream, lying but a few miles to the east of Cartersville, offers perhaps the most valuable power to be found anywhere on the course, and before the war was largely utilized by extensive manufacturing works, which stretched for half a mile along the river, and which represented an investment of $500,000 or more. There were three blast-furnaces, a rolling-mill, a foundery, a nail factory, and a flouring-mill with a capacity of 300 barrels per day. The flouring-mill and rolling-mill are said to have been the first of any importance established south of Richmond. Previously New York flour, known here as "Canal flour", had monopolized the southern markets, and in this section commanded $20 per barrel; but with this the new product competed, with the greatest success, in all the southern markets, and finally in New York city. Immediately preceding the war, arrangements had been completed between Major M. E. Cooper, owner of the property on the Etowah, and still residing near by, and Colonel Samuel Colt, of Hartford, Connecticut, to engage jointly in the manufacture of fire-arms at the locality here described, but the breaking out of hostilities prevented the removal of any part of Colonel Colt's works, although it is stated that the necessary papers had been signed, and that a month more of time would have seen the undertaking carried out. In 1864, during Sherman's campaign, the buildings here were all burned, and only the ruins of what were very substantial structures now remain.

The property embraces 15,000 (?) acres of land, extending more than 5 miles along the Etowah river, on both sides, and probably covering a fall of at least 80 feet on that stream, though the exact amount could not be ascertained. It also includes Allatoona and Stamp creeks, tributaries of the Etowah, each with large fall and abundant power. Running from the old works down the river-bank to the line of the Western and Atlantic railroad was a branch track, the graded line of which still remains in good condition, and which, though now without ties or rails, might easily be put in condition for traffic. The property is owned by an incorporated company, the Etowah Manufacturing & Mining Company, with offices in Savannah, and is offered for sale, in one piece only, at a nominal price of $100,000.

Estimate of power at the Etowah Mining & Manufacturing Company's privilege.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*	20 *feet fall.*	80 *feet fall.*
Low water, dry year	15	13	10	15½	53½	1,060	370	42.0	420	840	3,360
Low water, average year							560	63.6	636	1,272	5,088
Available 10 months, average year							750	85.2	852	1,704	6,816

The large fall in this section of the river occurs where the latter has cut its way through a spur of the Blue ridge. The stream flows with rapid current and almost constant ripples, now and then pitching abruptly over a low ledge. The bed is generally rock and contains numerous large bowlders, and here and there a small island appears. The average width between banks is probably 200 or 300 feet, although in places it increases to 500 or 600 feet. As the power was formerly developed there were two dams across the river, built of logs, each structure 10 feet high; they were about half a mile apart, the upper dam at the rolling-mill and the lower at the flouring-mill. The entire 80 feet or more of fall could perhaps best be improved in several successive privileges of say 20 feet each. The abundance of timber and stone should render the expense for dams reasonable, and perfectly secure foundations

could be obtained without difficulty. The ground rises rather abruptly on the south side of the river; the old works were on the north side, where the immediate bank is succeeded by a level stretch, elevated from 8 to 20 feet above the water and extending back from 75 to 150 feet before reaching the abrupt ascent of the mountain. The power to be obtained here is large, and the site well deserves attention.

No power was learned of as in use below Cartersville. There had been a dam and a small grist-mill a short distance down from the Western and Atlantic Railroad crossing, but they were in the main carried away during the exceptionally high freshet in the spring of 1881. For the remainder of the distance to its mouth the river has a quite uniform and moderate slope, with an average width of perhaps 250 feet. The bed is rocky, and the banks are of tolerably good height. This part of the stream is more under the influence of backwater than that above, but could probably be utilized for falls of from 5 to 8 feet.

The tributaries of the Etowah are small, no one draining more than 240 square miles. A list of the principal ones is given below. The districts through which they run abound in large springs and brooks of fine "freestone water", and are well adapted to the cultivation of cotton, corn, wheat, oats, barley, fruits, and vegetables. Although the streams are not large, many of them have sufficient volume and fall to support manufacturing works of some importance, at least during the greater part of the year. Stamp creek has one or two small furnaces, and there is a small cotton factory on Shoal creek.

Drainage areas of the Etowah river and principal tributaries.

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Etowah river at Aurama, Lumpkin county	100	Mountain creek	77
Etowah river at High Tower, Forsyth county	356	Shoal creek	66
Etowah river at Canton, Cherokee county	677	Little river	239
Etowah river below Shoal creek	769	Allatoona creek	100
Etowah river at Etowah Iron Works	1,060	Pettis creek	56
Etowah river below Allatoona creek	1,213	Pumpkin Vine creek	131
Etowah river near Cartersville (railroad crossing)	1,226	Raccoon creek	60
Etowah river at mouth	1,940	Euharlee creek	205
Armacolola creek	116	Two-Run creek	47

THE OOSTENAULA RIVER AND TRIBUTARIES.

The Oostenaula river, which unites with the Etowah at Rome to form the Coosa, is in turn made up, near Resaca, in Gordon county, Georgia, by the junction of the Coosawattee and the Conasauga. It flows thence in a crooked southwesterly course, having a length of about 60 miles. It is navigable, but is very little navigated. The area drained above its head is 1,606, and above the junction at Rome 2,190 square miles.

The Coosawattee river heads in Gilmer county, Georgia, running southwesterly to Resaca. For 45 miles above its mouth, to Carter's Landing, the river is navigable during six months in the year, and some work has been done by government engineers in improving the channel, but the actual amount of traffic carried on is slight. In this 45 miles the fall is moderate and the stream winds about among exceedingly rich bottom-lands, on which corn, wheat, and cotton are raised. Just above Carter's Landing the meadows cease and the river issues from a narrow valley in the mountains. Here is met the first dam, a log structure 400 feet, more or less, in length and 8 feet high. A fall of 9 feet is obtained and power used for a 2-run grist-mill, a saw-mill, a tannery, and a cotton-gin. There is a large surplus power here, even with the present head, and, except that the railroad facilities are poor (the nearest railroad station is Calhoun, on the Western and Atlantic railroad, 18 miles distant by wagon-road), the site is well suited to more extensive improvement. On one side the mountain rises several hundred feet almost vertically from the water, while on the other side, on which the mills are located, there is a gradual ascent at first, favorable to carrying a canal, if desired. The hills recede immediately below and leave abundant room for mills of any size and a village.

Estimate of power near Carter's Landing.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*9 feet fall.*
Low water, dry year	15	13	10	15½	53½	550	190	21.6	190
Low water, average year							290	32.9	300
Available 10 months, average year							390	44.3	400

Mr. Samuel Carter, of Dalton, is the proprietor of the privilege described, and also owns for some 2 miles along the river in this vicinity. The dam sets the water back for half a mile, beyond which the stream becomes rapid, with hardly a stretch of smooth water more than a few hundred feet in length. A railroad survey has been extended

some little way above, and the fall thus ascertained is said to range from 10 feet in 900 feet to 10 feet in half or three-quarters of a mile. For some distance above Carter's Landing the width between banks is stated to be from 200 to 300 feet, and the fall to be sufficient to furnish, within 2 miles, several privileges of about 10 feet each. At the end of 2 miles there are two abrupt falls, one of 18 and the other of 20 feet; but the river is described as being there so closely wedged between high and almost vertical cliffs that it would be very difficult to improve. Above this point the river winds its way among the mountains, which rise steep, wooded, and high directly from its banks. The bed is mostly freestone, the fall rapid and constant, but there are no mills, certainly up to the junction of the Ellijay and Cartecay which are the principal branches of the Coosawattee. The wagon-road which leads to Carter's mill also extends up to the falls, and there stops, the rocky obstructions being impassable; and for any mills using power for some distance above, a new road would have to be constructed up over the bordering mountains, although that is not impracticable.

This stream holds its own very well in the dry season, but rises and falls rapidly after heavy storms, especially in late winter, when the ground has become thoroughly soaked; the height of a freshet is usually reached within 12 hours from the beginning of the rise, and the fall is nearly as rapid. At Carter's Landing the water has in an extreme case reached a height of 15 or 20 feet above a low stage, but this was largely backwater from below, and farther up stream the rise was much less. The Coosawattee drains 929 square miles.

The Conasauga river has its source in Fannin county, Georgia, a little below the Tennessee boundary; it takes a short turn into the latter state and then flows southerly into Georgia again, forming the division between Murray and Whitfield counties, and in Gordon county uniting with the Coosawattee. It drains 677 square miles, but appears to have little importance for power. It is in general a flat stream, with rather sluggish flow, running wide and shallow, and in summer almost dry, at any rate scarcely more than 20 feet wide in places. Toward the extreme head-waters it has more fall, and may be of slight value. It is used by only a few scattering saw- and grist-mills. Being rather a long stream with slight fall, it runs out much more slowly than the Coosawattee, so that after the latter has discharged its surplus water it is liable to be kept up for some time by backwater from the Conasauga.

Drainage areas of the Oostenaula river and tributaries.

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Conasauga river below Cooyehuttee creek	485	Mountain Town creek (tributary to Coosawattee)	79
Conasauga river at mouth	677	Talking Rock creek (tributary to Coosawattee)	165
Cooyehuttee creek (tributary to Conasauga)	174	Free Bridge (?) creek (tributary to Coosawattee)	262
Rocky creek (tributary to Conasauga)	88	Oostenaula river at Resaca (below junction)	1,606
Coosawattee river at Ellijay (below junction)	233	Oostenaula river at Rome (above junction)	2,190
Coosawattee river at Carter's Landing (below Talking Rock creek)	550	Adairsville (?) creek (tributary to Oostenaula)	76
Coosawattee river at mouth	929	Armucha creek (tributary to Oostenaula)	233

Table of utilized power on tributaries of the Alabama river.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Alabama river	Mobile river	Alabama							River navigable.
Sundry small tributaries.	Alabama river	do	Autauga	Cotton	1				
Do	do	do	do	Cotton-gins manufactured.	1	17½	250		Prattville.
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Sashes, doors, and blinds	1				
Do	do	do	do	Cotton-gins	6	34+	46		
Do	do	do	do	Flouring and grist	19	173+	174		
Do	do	do	do	Flouring and grist, and cotton gins.	5	57	53		
Do	do	do	do	Saw	5	37	120		
Do	do	do	Baldwin	do	1	12	160		
Do	do	do	Butler	Flouring and grist	1	7	6		
Do	do	do	Chilton	do	1	8	8		
Do	do	do	Clarke	do	3	32	26		
Do	do	do	Elmore	do	6		30		
Do	do	do	do	Saw	5	10+	62		
Do	do	do	Lowndes	Flouring and grist	1	20	10		
Do	do	do	Marengo	do	1	15	40		
Do	do	do	Monroe	do	11	31+	78		

Table of utilized power on tributaries of the Alabama river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Sundry small tributaries.	Alabama river	Alabama	Monroe	Saw	3	27	35	....	
Do	do	do	Wilcox	Flouring and grist	4	15+	65	....	
Cahaba river and tributaries.	do	do	Perry	do	7	51	48	....	
Do	do	do	Bibb	do	4	37½	59	....	
Do	do	do	Shelby	do	7	62	144	....	Three of these are on the Cahaba and East branch.
Do	do	do	do	Saw	1	10	8	....	East Cahaba.
Do	do	do	Jefferson	Flouring and grist	3	30	39	....	Head-waters of main river.
Tallapoosa river	do	do	Elmore	Cotton	1				
Do	do	do	do	Cotton-gin	1				
Do	do	do	do	Carpenter-shop	1				
Do	do	do	do	Flouring and grist	1				
Do	do	do	do	Foundery and blacksmith shop.	1	24–32	900±	....	Tallassee falls; over 1,100 rated horse-power of wheels in place.
Do	do	do	do	Pump for village water-supply.	1				
Do	do	do	do	Saw	1				
Do	do	do	Tallapoosa	Flouring and grist	1	9	10	....	
Do	do	Georgia	Haralson	do	3	16	67	....	
Do	do	do	do	Saw	1	7	12	....	
Do	do	do	Paulding	Flouring and grist	1	10	10	....	
Tributaries	Tallapoosa river	do	Haralson	do	7	71½	92	....	
Do	do	do	do	Saw	1	6	5	....	
Do	do	do	Carroll	Cotton-gin	1	6	....	....	
Do	do	do	do	Flouring and grist	10	142+	151	....	
Do	do	do	do	Saw	3	32	36	....	
Do	do	do	do	Tannery	1	24	6	....	
Do	do	do	do	Woolen	2	20	9	....	
Do	do	Alabama	Macon	Flouring and grist	3	36+	33	....	
Do	do	do	Bullock	do	1	27	8	....	
Do	do	do	Elmore	do	5	72	112	....	
Do	do	do	do	Cotton-gin	1	....	30	....	
Do	do	do	Tallapoosa	Flouring and grist	8	144	118	25	
Do	do	do	Lee	do	3	67½	74	....	
Do	do	do	do	Furniture works	1	8	6	....	
Do	do	do	Chambers	Flouring and grist	8	103	98	....	
Do	do	do	Clay	do	14	128+	168	....	
Do	do	do	do	Saw	3	32	38	....	
Do	do	do	Cleburne	Flouring and grist	9	74	91	....	
Do	do	do	Randolph	do	13	171	291	....	
Do	do	do	do	Saw	3	42	65	....	
Do	do	do	do	Wheelwrighting	1	7	15	....	
Coosa river	Alabama river	do	Saint Clair	Flouring and grist	1	3½	15	....	
Sundry small tributaries.	Coosa river	do	Elmore	do	4	32+	104	....	
Do	do	do	do	Cotton-gins	2	....	18	....	
Do	do	do	Coosa	Flouring and grist	15	253	282	....	
Do	do	do	do	Saw	3	61	51	....	
Do	do	do	Shelby	Flouring and grist	9	101	185	35	
Do	do	do	do	Saw	2	30	41	....	
Do	do	do	do	Tannery	1	11	39	....	
Do	do	do	Talladega	Flouring and grist	10	56½	264	....	
Do	do	do	do	Saw	4	23	57	....	
Do	do	do	do	Blacksmith-shop	1	6	6	....	
Do	do	do	Clay	Flouring and grist	7	65	89	....	
Do	do	do	do	Saw	2	17	33	....	
Do	do	do	Saint Clair	do	4	41	115	....	
Do	do	do	do	Flouring and grist	4	46	68	....	
Do	do	do	Calhoun	do	12	116½	261	....	
Do	do	do	do	Saw	2	18	25	....	
Do	do	do	do	Tanneries	2	11	18	....	
Do	do	do	Cleburne	Flouring and grist	4	36	67	....	
Do	do	do	do	Saw	1	8	5	....	
Do	do	do	Etowah	Flouring and grist	8	92½+	180	....	
Do	do	do	De Kalb	do	5	45½	44	....	
Do	do	do	do	Saw	1	4½	8	....	
Do	do	do	Cherokee	do	2	14	28	....	
Do	do	do	do	Tannery	1	8	5	....	

Table of utilized power on tributaries of the Alabama river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
Sundry small tributaries.	Coosa river	Alabama	Cherokee	Flouring and grist	14	149	196	....	
Do	...do	Georgia	Floyd	...do	14	183	204	....	
Do	...do	...do	...do	Saw	3	37	43	....	
Do	...do	...do	...do	Woolen	2	15½	17	....	
Do	...do	...do	...do	Cotton-gins	2	23	20	....	
Do	...do	...do	Polk	Blacksmith-shop	1				
Do	...do	...do	...do	Flouring and grist	1	4	70	....	Cedartown.
Do	...do	...do	...do	Machine-shop and foundery	1				
Do	...do	...do	...do	Wood-working shop	1				
Do	...do	...do	...do	Flouring and grist	6	125	138	....	
Etowah river	...do	...do	Dawson	Carpenter-shop	1				
Do	...do	...do	...do	Flouring and grist	2	18	58	....	
Do	...do	...do	...do	Saw	1				
Do	...do	...do	...do	Tannery	1				
Do	...do	...do	...do	Stamp-mill	1	....	....	....	
Do	...do	...do	...do	Flouring and grist	4	83	50	....	
Do	...do	...do	...do	Saw	2	42	27	....	
Tributaries	Etowah river	...do	Polk	Flouring and grist	2	30	40	....	
Do	...do	...do	Floyd	...do	2	16	47	....	
Do	...do	...do	Bartow	...do	14	156	318	....	
Do	...do	...do	Paulding	...do	9	107	79	....	
Do	...do	...do	...do	Saw	2	24	34	....	
Do	...do	...do	...do	Woolen	1	12	4	....	
Do	...do	...do	Cobb	Flouring and grist	2	26	26	....	
Do	...do	...do	Cherokee	...do	12	195	187	....	
Do	...do	...do	...do	Cotton	2	25½	56	....	
Do	...do	...do	...do	Saw	5	78	64	....	
Do	...do	...do	Pickens	...do	5	54	50	....	
Do	...do	...do	...do	Furniture	2	15	20	....	
Do	...do	...do	...do	Flouring and grist	13	179	129	....	
Do	...do	...do	Milton	...do	2	28	16	....	
Do	...do	...do	...do	Wheelwrighting	1	12	6	....	
Do	...do	...do	...do	Saw	4	68	74	....	
Do	...do	...do	Dawson	Flouring and grist	2	38	40	....	
Do	...do	...do	...do	Woolen	1	....	8	....	
Oostenaula river	Coosa river	...do	....	....	....	....	....	....	River navigable.
Coosawattee river and tributaries.	Oostenaula river	...do	Bartow	Flouring and grist	5	56	74	....	
Do	...do	...do	Gilmer	...do	3	61	48	....	
Do	...do	...do	Gordon	Flouring and grist	5	44	160	....	
Do	...do	...do	...do	Cotton-gin	1	....	....	....	
Do	...do	...do	...do	Saw	1	....	....	....	
Do	...do	...do	...do	Tannery	1	....	....	....	
Do	...do	...do	Pickens	Cotton	1	18	432	....	
Do	...do	...do	...do	Flouring and grist	10	141	116	....	
Do	...do	...do	...do	Saw	1	12	10	....	
Do	...do	...do	...do	Woolen	1	18	20	....	
Conasauga river and tributaries.	...do	...do	Murray	Flouring and grist	8	93	105	....	
Do	...do	...do	...do	Saw	2	28	30	....	
Do	...do	...do	Whitfield	...do	2	20	22	....	
Do	...do	...do	...do	Flouring and grist	12	161½	151	....	
Do	...do	...do	...do	Boots and shoes	1	7	6	....	
Other tributaries	...do	...do	Bartow	Flouring and grist	4	56	52	....	
Do	...do	...do	...do	Woolen	2	17	13	....	
Do	...do	...do	Chattooga	Cotton-gin	1	10	7	....	
Do	...do	...do	...do	Flouring and grist	6	74	112	....	
Do	...do	...do	...do	Saw	3	43	50	....	
Do	...do	...do	Floyd	Flouring and grist	3	24	141	....	
Do	...do	...do	Gordon	...do	3	43	24	....	
Chattooga river and tributaries.	Coosa river	...do	Chattooga	Cotton	1	16	300	....	
Do	...do	...do	...do	Cotton-gins	4	24+	40+	....	
Do	...do	...do	...do	Flouring and grist	7	92	145	....	
Do	...do	...do	...do	Saw	5	63	102	....	
Do	...do	...do	...do	Woolen	1	13½	8	....	
Do	...do	Alabama	Cherokee	Flouring and grist	3	21½	60	....	
Do	...do	...do	...do	Iron-works	1	8	....	....	

THE APPALACHICOLA RIVER AND TRIBUTARIES.

Being a navigable river, the Appalachicola is not itself to be considered with reference to water-power. It is formed on the northern boundary between western Florida and Georgia by the union of the Chattahoochee and Flint rivers. From their junction it runs in a southerly direction to the Gulf, having a length, by straight course, of about 70 miles.

Drainage areas.

	Square miles.
Chattahoochee river	9,100
Flint river	8,420
Appalachicola river below junction	17,520
Appalachicola river at mouth	19,580

THE CHATTAHOOCHEE RIVER.

The sources of this river are in Habersham and White counties, in northern Georgia, whence it takes a very direct southwesterly course across the state; in Heard and Troup counties it turns southerly, and continues in that direction until at the extreme southwest corner of the state it unites with the Flint river. From West Point down it forms the boundary between Georgia on the one side, and Alabama and a portion of Florida on the other. From the junction of the Soquee and Sautee rivers to its mouth the Chattahoochee has a length by general course of about 315 miles, but the actual distance by water is probably twice as great. Rising and flowing as far as Columbus upon the metamorphic rocks, the stream is frequently obstructed by shoals, rapids, and low falls, creating valuable opportunities for the development of water-power. At Columbus the falls come to an end, and below that point the river is navigable throughout the year to the Gulf, an estimated distance by water of about 400 miles, for steamers of 2½ or 3 feet draught, carrying as high as 750 bales of cotton. Immediately at the head of navigation a fall of 25 feet is in use by large cotton-mills, and within 4½ miles there is a total descent of about 120 feet, mainly unimproved. It is fortunate for manufacturing-purposes that the fall of the river is heaviest well down in its course, where the volume is large and navigable waters are near at hand. Within 34 miles above Columbus, measuring from the head of navigation, there is a fall of 362 feet, or as much as occurs in the entire 170 miles succeeding, reaching nearly to the head-waters.

Table showing the fall in the Chattahoochee river.(a)

Locality.	Approximate distance from Gulf.	Elevation above tide.(b)	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Thompson's bridge, near Gainesville	615	989			
			73	227	3.11
Western and Atlantic Railroad crossing near Atlanta	542	762			
			108	162	1.50
Atlanta and West Point Railroad crossing at West Point	434	600			
			34	362	10.65
Columbus, head of navigation	400	238			
			400	238	0.59½
Mouth of Appalachicola river	0	0			

a Data taken from report of survey made under direction of Major W. R. King, Corps of Engineers, U. S. army.
b Elevations are for low-water surface of river.

Almost the entire course of the river in that portion having value for power is upon a bed of solid rock, with scarcely any sand or gravel bars. For 30 miles above Thompson's bridge, in Hall county, there are said to be few shoals, but farther up they appear more frequently and there is a rapid current. At Seven-Island ford, near Belton, the stream is wide, and there is a long shoal where it was proposed to take out water for a canal to secure navigation by a cross route from the Mississippi to the Atlantic. A few miles from Mount Airy, in Habersham county, there is stated to be a fall of some 75 feet in 3 miles, about 20 feet occurring in rapid pitches in a short distance. The place is described, however, as being not especially favorable for improvement, since the river flows between high and steep rocky bluffs; but it is said that by running a canal or a flume, at considerable expense, below the narrows an open and very favorable site for buildings might be found.

The entire river between Thompson's bridge and Columbus, a distance of 215 miles, was surveyed in 1879 by government engineers under the direction of Major W. R. King, and the results of their examinations are to be found in the *Report of the Chief of Engineers for* 1880. The only practicable method of extending navigation over this stretch was found to be by a system of locks and dams, the estimated expense of which—$4,870,000 for construction alone—is so great that there is little probability of the work being undertaken. Over the portion of the river surveyed the width in the narrower places gradually increases from 200 to 600 or 700 feet, while on the shoals the width runs as high as 600 feet between Thompson's bridge and the Western and Atlantic Railroad crossing, 1,200

or 1,300 feet thence to West Point, and even reaches half a mile in places between West Point and Columbus. A considerable portion of these extreme widths is usually taken up by islands, which are common at the shoals and are an especially valuable feature of the river with reference to its water-power. The width and volume, anywhere except in the extreme upper waters, are generally so great as to render the control of the entire stream too costly except for enterprises of magnitude; but by taking advantage of chutes or narrow channels occurring between the islands and the main shores, or between the islands themselves, powers of much variety, both as regards fall and volume of water, may be secured at reasonable outlay, and sometimes at a ridiculously small expense. In the vicinity of Columbus and West Point three powers have been obtained in the manner indicated, each serving to run a cotton factory of 4,000 or 5,000 spindles, and farther up stream there are said to be grist-mills supplied in the same manner.

As stated in the report of the engineers' survey, the Chattahoochee above Columbus has usually a gentle current except where interrupted by shoals and falls; these are frequent, however, especially in the section below West Point. The banks are quite uniform and of good height, here and there varied by fertile bottoms, and occasionally rising to precipitous rocky heights, as between Roswell and the Western and Atlantic Railroad crossing. The oscillations between low and high water are sudden and heavy, though varying, of course, according to the section of river and the local slope. Assistant Engineer D. L. Sublett, of the government surveying party, mentions that early in January, 1879, there was a rise of 14 feet in 12 hours at Thompson's bridge. The extreme oscillation at that point is given as 24 feet; at Garner's bridge, 17 feet; at Roswell bridge, 11 feet; at the Atlanta and West Point Railroad crossing, 25.6 feet; and at Columbus, below the falls, 42 feet.

Very little, comparatively, of the great power offered by the Chattahoochee has yet been put to employment. At Columbus are the famous Eagle & Phœnix mills, and moderate powers are also in use in that city and the vicinity by two other cotton-mills, and by an equal number near West Point, carrying a few thousand spindles each. Farther up stream there are reported to be occasional grist-mills, but the entire aggregate of power utilized on the river is insignificant in proportion to the amount available. The freedom from ice and drift is a favorable feature of this stream. Its supplies are largely derived from springs, which give it a tolerably uniform flow. The very large fall occurring within 30 miles or so of the head of navigation, and indeed even within 5 miles; the situation in the midst of a cotton-growing section; the possession of an extremely healthful climate by the adjoining country, and the impetus already gained by the establishment of successful enterprises, should combine to render that portion of the river of great future importance in cotton-manufacturing. It is to be borne in mind also that the state of Georgia exempts from taxation for 10 years all new mills devoted to that industry. One present disadvantage to the development of power is the lack of suitable railroad facilities for the immediate river. The latter is crossed by lines at Columbus, West Point, northwest of Newman, and a few miles from Atlanta, but is nowhere else directly reached by railroad above the head of navigation; and though for 180 miles above West Point its general course is followed by the Atlanta and West Point and the Atlanta and Charlotte Air Line railroads, yet they are usually at distances from it of from 4 to 10 miles.

The only places of special importance immediately upon the river are Fort Gaines and Eufaula, on the lower course, with populations of 900 and 3,800, respectively; Columbus with 10,000, and West Point with 1,200. The country drained is rich, and is fairly well settled along the railroads. It bears a large amount of timber, including the long-leafed pine, white oak, hickory, chestnut, poplar, and in southwestern Georgia cedar and cypress also. The bottom-lands along the river yield valuable crops of corn and cotton. In the upper basin, particularly in the section drained by the Sautee and Chestatee branches, in the Nacoochee and Yahoola valleys, hydraulic gold-mining is extensively and profitably conducted. Copper is said to be found to some extent in Carroll and Fulton counties, and iron in Harris county.

Power at Columbus and vicinity.—The shoals and rapids which characterize all the upper river, and which are formed by the hard metamorphic rocks belonging to this part of the Appalachian system, reach the southern boundary of that extensive range and cease at Columbus. A few hundred feet below the Eagle & Phœnix dam the last outcrop appears, and it is said that no rock is to be seen on the river below. The material over which the stream takes its final plunges is granite and gneiss, claimed to be much harder than Quincy granite, and rendering difficult and expensive the construction of hydraulic works. The immediate banks in this vicinity are in general high, steep, and rocky, rising farther back to hills, beyond which stretches, on the Georgia side at least, a level tract well cultivated in corn and cotton.

The fall which is usually classed as lying near Columbus begins at a point some 4 miles above the city, on property owned by the Columbus Manufacturing Company. A fall of 48 feet 8 inches is covered by its possessions, which extend for a mile along the stream.(*a*) The only improvement of this fall is by the company itself, which manufactures sheetings and shirtings, utilizing 18 feet and about 150 horse-power. At the site of its factory the river spreads out to a width of from a quarter- to a half-mile, is full of rapids, and is dotted by numerous rocky islands. The banks are generally abrupt, and are perhaps from 75 to 150 feet high. Advantage has been taken of an old slough of the river on the east side, and, by throwing a few logs across between a couple of islands, sufficient

a The ownership of property on the Georgia side also extends by law to high-water mark on the Alabama side.

water has been diverted to the mill, below which the continuation of the channel of the slough serves as a tail-race. The Columbus Manufacturing Company has a capital stock of $250,000, and runs 4,100 spindles and 134 looms. It is considered that, by building a dam across the river farther up stream within the company's lines, water could conveniently be brought down the Georgia side in a canal, and the greater part of the fall, if not the entire amount, rendered available for manufacturing. The dam need not be more than 4 feet high, and would rest upon a natural ledge which crosses the river.

The next below is known as the "Cooke privilege" and is entirely unimproved. It embraces a total fall of about 38 feet, which is naturally divided into two falls of 26 and 12 feet, respectively. The upper fall, of 26 feet, is formed by a long shoal. At its foot a natural dam, perhaps 8 or 10 feet high, extends out from the Georgia side, opposite a precipitous point called Lover's Leap, nearly to the Alabama shore. A channel is left on that side, through which the whole ordinary flow of the stream rushes, afterward following along the lower face of the obstructing ledge, nearly to the Georgia side, when it turns south again and passes on toward Columbus. If the Cooke privilege were to be improved in two separate falls a dam would probably be built upon the upper shoal and a canal run down the Georgia bank. To take advantage of the lower fall the channel on the Alabama side, opposite Lover's Leap, would naturally be closed or cut off from above, and water carried in a flume from the Georgia end of the natural dam a short distance down the bank. It is thought that a fall of 20 feet could thus be secured, and the slough in the river would serve as a tail-race. It is considered by good judges, however, that the best plan would be to develop the privilege as a whole, by bringing water down from the upper shoal far enough to render available the entire fall. In any case this power would probably prove an expensive one to develop thoroughly, and, on account of the high, steep, and rocky banks, is not favorably situated for use. It has been suggested that power might be transferred to the top of the banks from below by cable; but although this plan might answer for powers of moderate size, say 100 horse-power or less, experience elsewhere seems to indicate that for those of as high as 200 or 300 horse-power it is not well suited. As regards transportation, either of three courses is open; goods may be transferred by team half a mile to and from the North and South Georgia narrow-gauge railroad, or a spur-track may be carried that distance, or a track may be run a mile or two down the river-bank to Columbus. The privilege here described is for sale, and is worthy of careful attention.

The third privilege in order is occupied by Phillips' grist-mill, carrying 8 runs of stones and using about 100 horse-power. The dam was built in 1871, and cost about $4,000. It is a framed structure resting on a rock foundation, and is probably 500 feet or more in length by an average of 8 feet in height. The fall obtained at the mill commonly ranges from 6 to 8 feet, according to the stage of water. The rapid fall in the river above prevents much of a rise in that section during freshets; but at Phillips' mill we come within the influence of backwater from the lower river, though trouble from this source is not of long duration.

The remaining privilege to be noticed, and the one which brings us to the smooth water marking the head of navigation, is owned by the Eagle & Phœnix Manufacturing Company, and embraces a fall of about 25 feet. Cotton-manufacturing was begun here as early as 1850. The first dam was carried away, but the present one, built in 1865, has stood securely. It is a framed structure of the usual pattern, with a back-slope of perhaps 35 degrees. It is some 700 or 800 feet in length, and for the greater part of that distance ranges from 5 to 15 feet in height, according to the contour of the river-bed; but in one place the height above foundation is probably 30 or 40 feet. It rests throughout upon rock and has heavy masonry abutments. It originally ran quite directly across the river, but the washing of the bank on the Alabama side rendered it necessary to extend the dam with an offset up stream. The main mill of the Eagle & Phœnix company is on the Georgia side just below the dam. Its other mills, and the mill of the Muscogee Manufacturing Company, which leases power, are located at intervals along the bank above, opposite the pool formed by the dam. Between the mills and the pool runs the tail-race, protected on the river side by a splendid masonry wall perhaps 8 or 10 feet wide at the top. Spanning this race are heavy timber flumes conveying water from the pool to the mills. As has been stated, the extreme hardness of the rock at this point rendered work expensive, and the cost of the dam and the race-wall alone is estimated to have been $125,000.

The Muscogee mill, the uppermost along the race, uses a fall of 11 or 12 feet, and 130 or 140 horse-power; 4,500 spindles are run in the manufacture of sheeting, shirting, duck, and cottonade. The remainder of the privilege is occupied by the works of the Eagle & Phœnix company, comprising three principal mills and a large dye-house. This concern started up since the war, and in the spring of 1881 had a capital stock of $1,250,000, a surplus of $550,000, and a total investment of $1,925,000. There were at that time in employment 1,800 hands, and 53 bales of cotton, of 450 pounds each, were used per week. The machinery in the mills includes 44,000 cotton-spindles, 1,530 looms, and 7 sets of cards. Colored cotton goods, woolens, and cordage are manufactured, the production of cordage alone amounting to 3,000 pounds per day. The Eagle & Phœnix works use a total of about 1,700 horse-power for the principal mills, under heads of 16 and 25 feet. For electric lighting a 70 horse-power wheel is employed, and 100 horse-power is available for fire-pumps. Seven 80 horse-power boilers furnish steam, though not for power. At the new or main mill there is a head of 25 feet, and power is taken from 4 water-wheels—Swain turbines of 400 horse-power each. These wheels are in pairs, each pair geared upon a single shaft. Two wheels, one of each pair, give sufficient power with a full head, but the others are for additional use during backwater.

The slope of the river is very small below this point, and freshets cause a heavy rise, commonly forcing a stoppage of work at the mills for one or two days in the year. In the spring of 1881 there was a rise of 35 feet, and work was suspended for 15 days.

It may be seen from what has been said that there is a large amount of undeveloped power in the vicinity of Columbus. Its value is certainly great and the locality has important natural advantages. Considering, however, the size of the river and the nature of its banks, the extensive improvement of the fall would demand a heavy original outlay, and would probably be undertaken only by companies possessed of abundant capital. Hitherto the lack of this necessary resource, and an absence of special interest in manufacturing among the people of this section, have prevented, except in the notable instance of the Eagle & Phœnix company, the formation of such enterprises as the splendid powers to be obtained would warrant. As nearly as can be ascertained, the fall in that part of the river lying near Columbus is as follows:

Fall in the Chattahoochee river within about four miles of navigable water at Columbus.

Section of river.	Fall.	Remarks.
	Feet.	
Columbus Manufacturing Company's property	48.67	Only 18 feet of fall and a small part of the flow of the river utilized.
From Cooke's upper line to head of falls at Lover's Leap.	25.95	Entirely unimproved.
Thence to Cooke's lower line	11.63	
From Cooke's lower line to surface of Phillips' mill-pond.	1.19	
From Phillips' mill-pond to city line	7.86	Small power used by grist-mill.
Eagle & Phœnix Manufacturing Company's privilege	25.00	Utilized.
Total fall, about	120.30	

With no continued series of gaugings, and with but few data regarding the rainfall, or the flow in neighboring rivers, it is impossible to determine with much accuracy the power corresponding to this fall, but it may be estimated as follows:(a)

Estimate of power in the vicinity of Columbus, Georgia.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.(a)					
	Spring.	Summer.	Autumn.	Winter.	Year.			1 foot fall.	8 feet fall (Phillips' grist-mill privilege).	38 feet fall (Cooke's privilege).	49 feet fall (Columbus Manufacturing Company's privilege).	95 feet fall (aggregate of Phillips', Cooke's, and Columbus company's privileges).	120 feet fall (aggregate within say 5 miles of navigable water).
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*						
Low water, dry year	12¼	13	9½	14	49	4,800	2,500	284.0	2,270	10,790	13,920	26,980	34,080
Low water, average year							3,000	340.8	2,730	12,950	16,700	32,380	40,900
Available 10 months, average year							3,500	397.6	3,180	15,110	19,480	37,770	47,710

a With good wheels, from 60 to 80 per cent. of this may be realized in ordinary practice.

Power near West Point.—Above the upper line of the Columbus Manufacturing Company's property there is an "eddy", or quiet water, for three-quarters of a mile, and shoals then succeed for 3 or 4 miles. The river is said to preserve this general character all the way up to West Point, there being no abrupt falls of magnitude, but frequent rapids, constituting a valuable section for power. In this distance the river is reported to be usually wide, probably at least 1,000 feet, flowing through a district well covered with pine timber, amid hills similar to those at Columbus, the banks now high and steep and again low and flat. The bed is generally rocky. What is known as Jack Todd's shoal begins about 4 miles below West Point, and extends down stream 7½ miles, with a fall in that distance of 51.31 feet. In his report upon the survey of this portion of the river,(b) Mr. B. W. Frobel, assistant engineer, states that "the river varies here from 600 feet to half a mile in width, the channel being divided by numerous islands. The banks are high and formed of rock, and so are the islands".

Power is used at two different points on this shoal, both on the Georgia side. At the lower, distant about 7 miles by road below West Point, is the cotton factory of the Alabama & Georgia Manufacturing Company, running

a It should be stated, however, that during the construction, in 1882, of a new dam to supplant the old structure belonging to the Eagle & Phœnix Manufacturing Company, the river was so controlled that its volume could approximately be determined; and from a consideration of the data thus obtained, kindly furnished to the author by Mr. John Hill, engineer in charge of the work, it is believed that the discharge of the river has not been overestimated.

b See *Annual Report of the Chief of Engineers*, 1880 (p. 1713).

3,500 spindles and 100 looms. Some little distance up stream a dam has been thrown across between two islands to deflect the current to the east side; another dam runs from the mill to an island adjacent and secures sufficient water for use, though there is not commonly much surplus. Both these dams are crib-work structures partially filled with stone. The lower is several hundred feet long, and has an extreme height above foundation of 15 or 16 feet, averaging perhaps 11 feet; it was built in 1867. About 130 horse-power is in use under a head of 9 feet. Slight trouble is experienced from backwater, and during the spring of 1881 the mill was stopped six days from that cause. The company has a capital stock of, in round numbers, $260,000, and manufactures 8- and 10-ounce duck, using 9 bales of cotton per diem.

Two miles farther up stream is the next power in use. There, as at the privilege just described, the river is wide, studded with islands, bordered by high hills, and runs over a rocky bed. A dam has been thrown out from the Georgia side, controlling about one-third the width of the river. It was built in 1870–'73, and is quite long, running diagonally up stream, first to one island and then to another. In construction it is a dry-stone wall, 10 or 15 feet wide at the base, 6 feet wide at the top, and averaging about 5½ feet in height. Seven feet of fall and 50 horse-power are first used at Lanier's grist-mill. A separate short canal conveys water to the cotton factory of the West Point Manufacturing Company, where a fall of 8 feet and 160 horse-power are obtained. This company runs 5,000 spindles and 100 looms in the manufacture of cotton duck. At the time it was visited the mill was not running, but was being stocked with new machinery and was expected soon to be in operation again. Both the mills near West Point ship goods and material to and from that town, and are sometimes seriously inconvenienced by impassable roads.

Above this locality we come upon a section of the river where the fall is much less rapid than below. As far as Franklin it is described as having a good current, with occasional shoals, banks usually of but moderate height, and frequently low. The only use of power is by two or three small grist-mills, but it is said there are available unoccupied sites where falls of 7 or 8 feet may conveniently be obtained. The remainder of the river above has already been described in a general way, and there will only be added a list of the principal shoals, with their length and fall as determined by the government survey, and an estimate of the available power.

Estimate of power at the principal shoals in the Chattahoochee river below Thompson's bridge, Hall county (in order passing down stream).(a)

Name or location of shoal.	Approximate drainage area.	Length of shoal.	Fall on shoal.	THEORETICAL HORSE-POWER. (b) Low water, dry year.	Low water, average year.	Available 10 months, average year.	Remarks.
	Sq. miles.	Miles.	Feet.				
Shallow ford	590	1.04	6.71	160	280	370	3 miles below Thompson's bridge. River 300 feet wide, and divided at the upper end of the shoal by an island 1,600 feet long.
Johnson's shoal		0.68	3.17	70	130	170	Three-quarters of a mile below Shallow ford. River 200 feet wide; minimum depth in channel, 3 feet.
Overby's shoal	600	0.06	6.92	170	300	390	Immediately above mouth of Chestatee river. Main river 350 feet wide.
Brown's Mill shoal	960	1.61	(?)16.92	690	1,150	1,500	1 or 2 miles below Chestatee river. Stream widens to 600 feet.
Winding shoals and Garner's Bridge shoals.	1,060	2.24	16.90	770	1,290	1,650	
Island shoal	1,280	0.95	9.00	490	820	1,060	12 miles below Jones' ferry. River from 400 to 800 feet wide, and channel divided by two islands.
Roswell shoal	1,300	1.97	13.28	770	1,240	1,580	Average width of river about 600 feet.
From foot of Roswell upper shoal to foot of Bull's sluice.		2.00	40.00	2,320	3,730	4,770	River varies greatly in width, and channel is divided by many small islands. Fall given as nearly 40 feet.
Devil's race-course		2.00+	19.95	1,270	2,020	2,580	The "race-course" is 2 miles below Cochran's shoal, and the fall given is measured from the head of the latter. At the race-course the river is 450 feet wide.
Dimpsey's ferry		0.98	10.00	660	1,050	1,340	River 300 feet wide.
Pace's ferry		0.81	6.50	430	690	880	River 300 feet wide and filled with sunken reefs.
Mederis shoal	2,230	1.40	8.42	930	1,330	1,660	32 miles or more below Western and Atlantic Railroad crossing. River from 500 to 600 feet wide. Shoal consists of narrow reefs separated by deep pools.
McIntosh's shoals	2,620	0.72	7.24	930	1,340	1,680	River suddenly widens from 200 to 1,200 feet.
Hollingsworth's mill		0.14	3.51	450	660	820	
Bush-head shoal		0.40	5.17	680	980	1,230	6 miles or so above Franklin. River from 700 to 1,000 feet wide.
Daniel's Mill shoal		1.01	8.85	1,190	1,710	2,130	River 1,000 feet wide at head of shoal, and 300 feet wide just below it.
Jackson's mill, upper shoal	2,930	0.09	4.73	690	990	1,200	River 830 feet wide. Fall measured from above dam.
Huguley's shoal			8.00±	1,520	2,000	2,440	River varies from 600 to 1,300 feet in width, and is divided by several small islands.

a Owing to the lack of time and to the difficulty of reaching the stream directly by rail, the various falls not already described could not be examined in detail. The estimates of power here presented in connection with the different shoals pertain to the natural fall only; in case of the actual development of power the fall practically available would doubtless vary materially in individual cases from the figures here assumed, being dependent upon the location and height of dam and the length of canal employed.

b Based upon average flow for the 24 hours. With wheels of good pattern, from 60 to 80 per cent. of the theoretical power can be realized in practice.

Estimate of power at the principal shoals in the Chattahoochee river below Thompson's bridge, etc.—Continued.

Name or location of shoal.	Approximate drainage area.	Length of shoal.	Fall on shoal.	THEORETICAL HORSE-POWER.			Remarks.
				Low water, dry year.	Low water, average year.	Available 10 months, average year.	
	Sq. miles.	*Miles.*	*Feet.*				
Pott's shoal	3,580	0.69	5.06	980	1,290	1,580	A few miles above West Point.
Jack Todd's shoals	3,820	7.50	51.31	10,720	13,700	16,610	Extend from a point 4 miles below West Point to reef below Houston's ferry. River varies from 600 feet to half a mile in width, and channel is divided by numerous islands. Banks high and rocky. Power used at two points by cotton factories.
Three miles below Houston's ferry	4,300	0.19	4.00	1,000	1,230	1,460	
Hargett's island, and down stream to a small island 1,000 feet below the foot of Round island.	....	2.00–3.00	60.00±	15,200	18,610	22,090	The length and fall as stated for this section may not be exact, but are given as they appear from the estimates of locks and dams necessary to secure navigation. The shoals are 15 miles or more above Columbus.
From the foot of the small island to a point 4,000 feet below.	....	0.76	15.00	3,820	4,690	5,550	River contracts in width from 1,300 to 600 feet.
Thence down stream	....	0.66	16.00	4,110	5,040	5,960	
Thence down stream	....	0.98	10.00	2,590	3,170	3,750	River 1,100 feet wide.
Tate's shoals	....	1.02	22.00	5,700	7,000	8,300	From 11 to 12 miles above Columbus. River from 600 to 700 feet wide.
Mulberry Creek shoals	4,460	2.00	30.00	7,800	9,710	11,350	1 mile below Tate's shoals. River 1,000 feet wide.
Shoals from a point 4½ miles up stream down to navigable water at Columbus.	4,800	4.25	120.00	34,080	40,900	47,710	18 feet fall and moderate power obtained by wing-dam on upper part of shoals; 7 feet fall and small power used by grist-mill at Columbus; 25 feet fall and entire river controlled by dam of Eagle & Phœnix mills at Columbus. Fall is otherwise unimproved. River is wide and contains numerous islands.
Total of above shoals	....	....	528.64±	100,190	127,050	151,810	Total effective horse-power returned as in use on the entire main river in 1880, about 2,540.

NOTE.—The rainfall on the river basin may be taken as approximately 12½ inches in spring, 13 in summer, 9½ in autumn, 14 in winter, and 49 for the year.

TRIBUTARIES OF THE CHATTAHOOCHEE RIVER.

Although the drainage basin of the Chattahoochee has a length of over 300 miles, it is in comparison extremely narrow; at West Point it reaches a width of 35 miles, and at Columbus about 55, but elsewhere seldom exceeds 20 or 25 miles. From the upper waters down to Coweta county the southern water-shed is sharply defined, and is frequently but a few miles from the river. It passes through the city of Atlanta, the drainage of which is divided between the Chattahoochee river, running to the Gulf, and the Ocmulgee river, to the Atlantic. The elevated, hilly, and rocky character of the country above Columbus gives rise to numerous tributary streams which have considerable fall and furnish good opportunities for the use of power. The lower river, from Columbus to the mouth, is bordered by a narrow district, comparatively low and sandy, to the east of which is a region of marls and limestones. Where the small streams flow down from the latter formation to the first there are nearly always to be found falls—sometimes of great height—available for power. No information was gained of any important manufacturing in this section, although there are said to be one or two small cotton-mills in operation. Above Columbus the Chattahoochee receives thirteen tributaries draining upward of 100 square miles each, and seven below Columbus. Of the former, the Chestatee drains the largest area—330 square miles; while among the latter, and indeed among all the affluents of the main river, the Upatoi, which empties from the east a few miles below Columbus, ranks first, with a drainage area of 500 square miles. The limited time at command forbade direct examination of more than a very few of the affluents of the main river, but a description of some of those that have been developed by manufacturing enterprises of importance may be of value in conveying an idea of the probable character and capabilities of the rest.

Nickajack creek is a small stream, not more than 10 miles long, emptying from the north 8 miles to the west of Atlanta, and draining an area of 40 square miles. Its upper course lies in a rather flat country, after which it cuts through the hills and has a rapid descent. There are numerous small saw- and grist-mills on the creek, and power is also used by the Concord woolen-mill, running two sets of machinery on jeans and cassimeres. The dam is of rubble, without cement, and was built some 15 years ago at an estimated cost of $1,200. It is about 80 feet long, 20 feet high, and 21 feet wide at the base. A wooden flume conveys water 100 feet to the factory, where a 21-inch Burnham wheel is run under a fall of 21 feet. At times there is a little scarcity of water.

Soap creek lies near Marietta, to the northward from Atlanta, and is a short mountain stream running down with rapid fall over a rocky bed. Toward the mouth it ranges from 25 to 100 feet in width, averaging perhaps 50 feet. The banks are wooded, steep, and rocky. The stream itself is rapidly swollen by heavy rains, and quickly subsides again. Power is used for sundry small grist- and saw-mills and cotton-gins, but the only important manufacturing is about three-quarters of a mile from the mouth, where the Marietta Paper Manufacturing Company

has a mill. This company has a capital stock of $25,000, and manufactures news, book, and manila wrapping paper, turning out about 1,200 pounds per day. It does not make use of wood-pulp, and it is said that very little is employed in this section. The company owns land on both sides of the creek, embracing a fall of 65 feet in a quarter of a mile. The privilege at the mill is improved by a framed dam with stone abutments, the overflow about 100 feet long and 10 feet high. Water is carried 400 feet in a wooden flume, and used under a head of 22 feet on two breast-wheels, one 27 feet high and 18 feet wide, the other 22 feet by 5 feet. About 75 horse-power is estimated to be used, and it is thought that for six or eight months in the year 200 horse-power could be realized. During a protracted dry season, however, the creek runs very low, and the mill is sometimes more or less short of water for a period of three months. Much of this trouble occurs, though, at night, when water is held back in the mill-ponds farther up stream.

Neither this stream nor *Willeo creek*, which is near at hand, is of sufficient size to be indicated by name upon ordinary maps, and their drainage areas could not therefore be determined. Although they are small, it is evident that the aggregate of manufacturing which could be sustained by several such streams would reach very respectable dimensions. Willeo creek is of less importance than Soap creek, and is said to run nearly dry in summer. The only power worthy of notice is used at the Willeo mill, where a fall of some 30 feet is obtained, and about 1,200 spindles are run in the manufacture of yarns.

Vickery's creek enters the Chattahoochee from the right, 18 miles nearly due north of Atlanta. It drains an area of 94 square miles, including portions of Milton and Forsyth counties. Its course is entirely through a mountainous district, and it is hemmed in much of the way by high rocky banks, wooded and steep. The stream is a very rapid one, a succession of leaps and slides over ledges. As might be expected, sudden and violent freshets occur at times. In March, 1881, the creek was swollen by heavy rains to a furious torrent, with a volume estimated to have been twice as large as had ever before been observed, and swept away most of the dams and bridges along its course. It supplies power to the usual small saw-mills, grist-mills, and cotton-gins, besides a cotton factory and woolen factory. The latter are compelled to ship goods and material some 15 miles by team to and from Marietta, but a narrow-gauge spur is projected to run from Roswell southerly to the Atlanta and Charlotte Air Line railroad.

The lowest mill on the stream is close by the mouth, and belongs to the Laurel Mills Manufacturing Company, having a capital stock of $34,000, and running 2 sets of cards on woolen goods, jeans, tweeds, and linseys. Water is brought several hundred feet in a canal and wooden flume to the factory, furnishing power on the way to a small flouring-mill. At the woolen factory a 60 horse-power wheel is used, with a fall of 19 feet. No trouble is experienced from either low or back water. This privilege was formerly improved by a framed dam, but in 1871 this was in a manner replaced, at an expense of $5,000, by one of dry stone, cemented, however, on the face. The stone was laid in and upon the old dam without removing that structure. The new dam is 200 feet long and 18 feet high, with a width of 26 feet at the base. During the heavy March freshet already mentioned, water worked around one abutment and carried it and the bulkhead away, though the main portion of the dam was not injured.

This dam sets the stream back to the privilege occupied by the Roswell Manufacturing Company, about a mile and a quarter from the mouth. The company has a capital stock of $260,000, and is a large owner of property along the creek. Its business is carried on in a fine brick factory, in which are employed 225 hands, all native whites, some of whom have been in the constant service of the company for twenty or thirty years. The manufacture is largely in yarns, which are shipped to Philadelphia, but also includes some colored goods—checks and plaids—as well as sheetings and shirtings; 124 looms, of which 30 are on colored goods, and 8,400 spindles are run, and 9½ bales of cotton are used per day. The Roswell company formerly had three dams on the stream, but the lower, near its mill, which had been depended upon mainly for auxiliary power in low water, was carried away in the freshet which has been described as so disastrous along Vickery's creek. The upper dam, 3 miles above the mill, is a framed structure, and forms a pond extending back 3 miles, thus giving a large storage and furnishing a fall of 12 feet and the necessary power to a 3-run grist-mill. The main dam is of dry stone, cased with wood at the top, and was built about 1865. It is 120 feet long, 30 feet high, 30 feet wide at the base, and runs out to an edge at the top. From the dam, water is carried about 300 feet to the factory in a wooden flume 5 by 8 feet in size. Power is taken from a 60-inch American wheel running under a head of 27 feet. No trouble is encountered from backwater and very little from drought.

At Roswell the creek has a width, where running freely, of perhaps 50 feet. There is no other important manufacturing on its course than has been described, but there are said to be good unimproved sites for power.

The *Chestatee river*, the largest tributary of the Chattahoochee above Columbus, joins that river from the north, 6 miles west of Gainesville. It heads in the counties of Lumpkin and White, besides which it drains small portions of Hall, Dawson, and Forsyth counties. Its basin includes 330 square miles. The stream carries a large volume of water, has a rapid fall, and is valuable for power, although utilized for that purpose by only one or two small saw-mills. Bull's shoal is especially mentioned as offering a fine site. The width between banks is 150 or 200 feet in the lower course, and in the eddies there is an ordinary depth of 10 or 15 feet. As with all the other mountain streams, the freshets are sudden and heavy, with a rise of 12 or 14 feet in places. Along the stream is considerable good farming-

land, but at many points the valley is narrow and the banks rise abruptly. In the upper basin the mining of gold is an important industry, and on the bank of the Chestatee itself a mill has been erected, with apparatus designed for sucking up the material of the river-bed and extracting the gold.

The *Yahoola river* and *Cane creek*, tributaries of the Chestatee, are both small mountain streams flowing rapidly down over rocky beds, and used almost exclusively in the operations of gold-mining. In the vicinity of Dahlonega neither of them is more than about 20 feet wide. They are fed by springs, and are tolerably steady in flow most of the year, yet they run quite low in summer. The fall in the Yahoola from the head of the Hand canal to a point on the river some 16 or 17 miles by road farther down, lying a short distance south of Dahlonega, is 380 feet. In the remaining 1½ mile to the Chestatee there is a fall of 30 feet, with one or two good sites for power. Descending the Yahoola, there is first a small grist-mill, and then at Dahlonega the Benning mill, of 10 stamps; the Singleton mill, 10 stamps; the Hand Gold Mining Company's mill, 20 stamps, and the Findley mill, 40 stamps. These mills take power directly from the river, have timber and stone crib-work dams, as indeed the stamp-mills in this section generally do, and employ in most cases from 16 to 20 feet of fall. Two new mills had also been projected in the spring of 1881, of 24 and 40 stamps, respectively.

Although the stream is thus rendered very useful, its most important service is in supplying the canal of the Hand Gold Mining Company. Water is taken out from the Yahoola some 10 miles above Dahlonega and is brought along the side of the valley to the mines, where it is employed in washing for gold, but not for power. The main canal follows a sinuous course of 20 miles along the hill-sides, and then divides into two principal branches, which extend enough farther to give a total of about 40 miles of canal. Water is not drawn from the main canal, but only from the branches. The former is 6 feet wide, 3 feet deep, and has a grade of 4 feet to the mile. It was originally constructed about the year 1858, but was rebuilt soon after the war. For the most part its course lies in earth excavation, but there is also considerable rock-cutting. Until 1868 wooden trestles were used for crossing depressions, but they were then replaced by wooden and iron tubes. Of wooden tubing there is now in use 12,000 feet, including a single stretch a mile in length; 3,000 feet of 18-inch iron tubing is also in service. For 16 miles from its head the canal runs down the east side of the Yahoola, and then crosses. The transit is made in an iron tube which follows down and up the steep inclines that form the side-slopes of the valley. Over the stream which runs at the bottom the tube is supported, through a distance of about 160 feet, by wooden piers resting on stone foundations. The vertical depression overcome is 250 feet, and there is a fall of 6 feet between the ends of the pipe, which in a direct line are perhaps half a mile apart. The tube is of boiler-iron, 3,000 (?) feet long, 36 inches in diameter, and three-eighths of an inch thick at the bottom of the valley, gradually decreasing to half that thickness at the top.

Tributaries of the Chattahoochee river (in order from the source).

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Soquee river above junction with Sautee	149	Osannippa creek	127
Sautee river above junction with Soquee	151	Mountain creek	72
Mud creek	41	Big Hallewockee creek	98
Chestatee river at New Bridge	247	Wacoochee creek	39
Chestatee river at mouth	330	Mulberry creek	225
Suwanee creek	70	Standing Rock creek	75
Vickery's creek	94	Bull creek	70
Nancy's and Peachtree creeks	123	Upatoi creek	500
Nickajack creek	40	Uchee creek	325
Sweetwater creek	265	Hitchetee creek	73
Camp creek	76	Hannahatchee creek	98
Dog river	86	Hatcheechubbee creek	104
Snake creek	67	Nochefaloctee creek	52
Cedar creek	46	Cowikee river	475
Wahoo creek	34	Barbour creek	95
Sundalhatchee creek	59	Oketeeochenee creek	53
Hillabahatchee creek	123	Pataula (?) creek	425
New river	157	Comochechubbee creek	89
Yellow Jacket creek	185	Colomokee creek	82
Wehatkee creek	166	Yuttayabba creek	204
Occluhee creek	107	Ommussee creek	189
Long Cane creek	78	Sowahatchee creek	85
Flat Shod creek	225		

At Dahlonega the main canal divides, as has been said, into two branches. The larger of these supplies the Findley, Pennsylvania Consolidated, Bast & Ivey, Griscomb, Fish Trap, and Barlow mines, in the vicinity of Dahlonega, and the Chicago & Georgia mine at Auraria, 6 miles below. The other branch supplies the Benning, Hand, Hamilton, and Lockhart mines, the three former of which were not in operation at the time this locality was

visited. The total expenditure on account of the Hand canal is estimated to have reached $300,000, although such a canal could now be built for a very much smaller sum. The Hand Gold Mining Company sells the water to the various users at the rate of 12 cents per day per miner's inch, taken as the flow through a 1-inch aperture under a head of 4 inches. The operations of hydraulic mining are familiar, and a description would be out of place here. Although the proportion of gold in the ore of this section is commonly small, the cheapness with which the latter is treated, not exceeding from 25 to 35 cents per ton, renders mining a profitable industry.

Cane creek is similar to the Yahoola river. It has a rapid fall, which at one point becomes almost vertical through 50 feet. It is utilized by a small flouring-mill, and also by the Barlow stamp-mill, at which 16 feet of fall and about 60 horse-power are obtained.

THE FLINT RIVER.

Rising in western Georgia, within a dozen miles to the southward of Atlanta, this river takes a southerly course, bending well to the eastward toward Macon, and joins the Chattahoochee near the village of that name. The only important towns on its banks are Albany, in Dougherty county, with 3,200, and Bainbridge, Decatur county, with 1,400 inhabitants. From the mouth to Montezuma, a distance of 182 miles by water, the stream has been examined by government engineers with a view to rendering it navigable, and for several years more or less work has been performed along the lower course. The design is to secure a channel of the minimum dimensions of 100 feet width and 3 feet depth as far as Albany at least, and in 1880 the sum of $10,000 was appropriated by Congress for improvements between Albany and Montezuma. Up to June, 1880, inclusive, the entire appropriations to this river had amounted to $37,000, and the channel had been opened to a point about 10 miles above Bainbridge.(*a*) Above Albany the obstructions are snags and shallows, and, in particular, a series of rocky shoals stretching at intervals for some 18 miles up stream from the town.

The Flint river has a length by general course of about 230 miles and drains 8,420 square miles. But of this area not more than 1,200 square miles, or that part lying north of Talbot county, should be considered as contributing to available water-power on the main river. The interests of navigation would appear to forbid the damming of the stream below Montezuma, and above that point, as far up as Upson county, no important shoals were reported. According to the profiles of the Central Railroad of Georgia, between its crossings in southern Macon county and at Montezuma, a distance by water of not less than 22 miles, there is a fall in the stream of 41 feet.(*b*) From Montezuma to Albany the fall is given as, approximately, 125 feet for the 77 miles.(*c*) With a small average slope, and draining a section subject to heavy winter and spring rains, the river is visited by a large freshet-rise, ordinarily amounting to 10 or 15 feet as far north as the vicinity of Thomaston, in Upson county, but which was stated to have reached 25 feet in the spring of 1881. The river was visited at but one point, 8 or 10 miles from Thomaston. It was there found to be from 200 to 250 feet wide, flowing with a rapid current, being at the time somewhat above a mean stage. The banks were of sand and loam, with no appearance of rock; on one side they rose quite rapidly to a height of 50 or 75 feet, while on the opposite side they were not more than from 10 to 20 feet high, and were succeeded by a short stretch of bottom-land. It was said that this description would apply to many localities along the river in this section and below. But from the latitude of Thomaston up stream the slope becomes greater, the freshet-rise is less, the bed and banks display more or less rock, and there are frequent shoals with smooth water intervening. The upper river is not directly accessible by railroad, and is utilized only in a limited way for power by a few flouring- and grist-mills.

Drainage areas of the Flint river.

	Square miles.
At Erin, southwest corner of Spalding county, below junction with Lime and Whitewater creeks	560
Above Pigeon creek, northern boundary of Talbot county	1,190
Below Big Potato creek	1,690
At Montezuma, below Buck's creek	2,945
At Albany	5,430
At mouth of river	8,420

TRIBUTARIES OF THE FLINT RIVER.

As will be seen from a subsequent table, the Flint river receives two tributaries with a little over 1,000 square miles each of drainage area, one of between 600 and 700, while the remainder range from 260 square miles down. No special information has been obtained regarding any of these streams, excepting one or two in Upson county, but they do not appear to be used for important manufacturing. Above Thomaston they lie in the region of metamorphic rocks, and below mainly among the limestones and marls.

In a letter to the assistant engineer in charge of the Flint River survey (*d*) the secretary of the Albany board

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a *Report of the Chief of Engineers*, 1880.
b Elevations above tide, 306 and 265 feet, respectively.
c *Report of the Chief of Engineers*, 1879 (p. 820).
d *Report of the Chief of Engineers*, 1873.

of trade mentioned that 2 miles north of that city, on Kinahatoochee creek, there was a fine unimproved water-power capable of running 100,000 spindles. This stream has a drainage basin of 1,075 square miles, and with sufficient fall ought to furnish an important power.

Tobler creek is a short stream confined entirely to Upson county. It runs through a hilly district, has a sandy bed, and near the mouth is from 50 to 75 feet wide, with a good current. Owing to the clearing and cultivation of the land the channel has become somewhat filled up by the soil which is washed in. A mile or two from the mouth the Flint River Manufacturing Company uses a fall of 14 feet, and about 25 horse-power, in the manufacture of cotton yarns, consuming 60 bales of cotton per month. There is one other cotton factory on the stream, making sheetings and shirtings, besides several small grist-mills and cotton-gins.

Big Potato creek heads to the eastward of Flint river in Spalding county, flows southerly, passing through Pike and Upson counties, and joins the main river 7 or 8 miles south of Thomaston, its drainage basin containing 246 square miles. This stream has its sources in the mountains, receives supplies from many springs, and is well sustained in volume. Flowing among high hills, with a rapid fall over a rocky bed, and between high rocky banks which only occasionally give way to patches of bottom-land, the conditions are favorable for power. The stream drains considerable cultivated land, but also runs through much pine timber. There are numerous small flouring- and grist-mills along its course, and also good unimproved privileges. The most important of these brought to notice was one owned by Dr. C. Rogers, of Thomaston, and located some 3 miles from that town. The creek is there 200 or 300 feet wide, contains several small islands, and tumbles over two or three successive ledges in small falls of from 3 to 5 feet each. Within perhaps a quarter of a mile there is asserted to be a total fall of 60 feet available in two shoals of 30 feet each. Before the war Dr. Rogers had here a cotton factory of 1,800 spindles, and claims that each shoal will carry 5,000 spindles the year around.

Estimate of power at Rogers' privilege, near Thomaston.

Stage of water.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*30 feet fall.*	*60 feet fall.*
Low water, dry year	15	13	7½	15	50½	170	30	3.4	100	200
Low water, average year							50	5.7	170	340
Available 10 months, average year							75	8.5	255	510

Tributaries of the Flint river (in order from the source).

Name of stream.	Drainage area.	Name of stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Whitewater and Line creeks	246	Hog-craw creek	97
Texas (?) creek	184	Lampkin's creek	185
Red Oak creek	150	Line creek	73
Elkins creek	87	Gum creek	74
Cane creek	76	Cedar creek	48
Laxer creek	155	Swift creek	58
Big Potato creek	246	Chateefichickee creek	76
Little Potato creek	104	Jones' creek	55
Hootensville (?) creek	109	Abram's creek	140
Parchelagee creek	135	Pinewoods creek	57
Spring creek	85	Kinahatoochee creek	1,075
Whitewater creek	260	Pond creek	102
Buck's creek	205	Cooleewahee creek	105
Camp creek	64	Ichawaynocha and Kiokee creeks	1,083
Sweetwater creek		Spring creek	685

Table of utilized power on tributaries of the Appalachicola river.(a)

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Chattahoochee river (b)	Appalachicola river	Georgia	Muscogee	Cotton	c 3	43	2,000	
Do	do	do	do	Flouring and grist	d 1	8	100	
Do	do	do	Harris	do	e 1	7–8	50	
Do	do	do	do	Cotton	e 1		160	
Do	do	do	Troup	do	e 1	9	130	
Do	do	do	Hall	Building-materials	f 1	9	30	
Do	do	do	do	Flouring and grist	f 1		60	
Do	do	do	Cobb	do	1	11	10	
Sundry tributaries	do	Alabama	Henry	do	3	21	32	
Do	Chattahoochee river	do	do	do	16	129	148	
Do	do	do	do	Saw	4	15	56	
Do	do	do	Barbour	do	1	60	30	
Do	do	do	do	Cotton-gins	3	12+	75	
Do	do	do	do	Flouring and grist	7	47+	81	
Do	do	do	Russell	do	5	45+	121	
Do	do	do	do	Cotton-gin	1	7½	20	
Do	do	do	Lee	do	2	28	36	
Do	do	do	do	Flouring and grist	14	231+	319	
Do	do	do	do	Saw	1	16	8	
Do	do	do	Randolph	do	1	12	20	
Do	do	do	do	Flouring and grist	2	40	38	
Do	do	do	do	Stone and earthen ware	1	18	4	
Do	do	do	do	Cotton	1	32½	100	
Do	do	do	do	Woolen	1	35	60	
Do	do	do	Chambers	Flouring and grist	10	180	191	
Do	do	Georgia	Early	do	6	56½	72	
Do	do	do	do	Saw	1	......	25	
Do	do	do	Clay	do	3	29	60	
Do	do	do	do	Cotton-gin	1	8	6	
Do	do	do	do	Flouring and grist	6	58+	77	
Do	do	do	Quitman	do	4	49	96	
Do	do	do	do	Saw	2	24	63	
Do	do	do	Randolph	Flouring and grist	1	9	8	
Do	do	do	Stewart	do	8	83	192	
Do	do	do	do	Saw	2	20	22	
Do	do	do	Chattahoochee	do	1	10	15	
Do	do	do	do	Flouring and grist	6	57	75	
Do	do	do	Muscogee	do	4	73	213	
Do	do	do	Marion	do	1	6	12	
Do	do	do	do	Cotton-gin	1	8	21	
Do	do	do	do	Saw	1	8	30	
Do	do	do	Harris	do	1	12	10	
Do	do	do	do	Flouring and grist	13	235	398	
Do	do	do	Talbot	do	2	36	47	
Do	do	do	do	Saw	2	36	43	
Do	do	do	Troup	do	4	57	65	
Do	do	do	do	Tannery	1	22	8	
Do	do	do	do	Flouring and grist	22	223½	506	
Do	do	do	do	Cotton	1	20	50	
Do	do	do	Meriwether	Flouring and grist	1	30	11	
Do	do	do	Heard	do	8	91	101	
Do	do	do	do	Saw	3	124	125	
Do	do	do	Carroll	Cotton	1	30	120	
Do	do	do	do	Flouring and grist	12	277+	160	
Do	do	do	do	Saw	3	58	26	
Do	do	do	Coweta	Cotton	1	......	60	
Do	do	do	do	Flouring and grist	14	275+	226	
Do	do	do	Campbell	do	7	124	130	
Do	do	do	Douglas	Cotton-gin	1	11	20	
Do	do	do	do	Flouring and grist	13	202	119	

a Not including power employed in mining-operations in northern Georgia.

b About a dozen small flouring- and grist-mills are included in the census enumerators' returns as taking power from the main river in Carroll, Forsyth, and Heard counties, but it is probable that they are really located on small tributaries of the Chattahoochee, and they have been so classified here.

c At and near Columbus.

d At Columbus.

e Near West Point.

f Possibly not on main stream.

Table of utilized power on tributaries of the Appalachicola river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Sundry tributaries	Chattahoochee river	Georgia	Douglas	Saw	6	136	82	
Do	do	do	do	Tannery	1	60	10	
Do	do	do	do	Cotton	1		60	
Do	do	do	do	Woolen	1	14	9	
Do	do	do	Paulding	Flouring and grist	2	13	60	
Do	do	do	do	Saw	1	20	8	
Do	do	do	Cobb	Cotton	3	67	375	
Do	do	do	do	Woolen	2	40	85	
Do	do	do	do	Cotton-gins	9	135	111	
Do	do	do	do	Flouring and grist	23	368	454	
Do	do	do	do	Paper	1	22	75	
Do	do	do	do	Saw	5	45	69	
Do	do	do	Fulton	Cotton-gins	3	20+	22	
Do	do	do	do	Flouring and grist	8	156	106	
Do	do	do	do	Saw	3	30	31	
Do	do	do	De Kalb	Flouring and grist	7	120	119	
Do	do	do	do	Furniture	2	47	25	
Do	do	do	do	Saw	2	24	40	
Do	do	do	do	Tannery	1	15	10	
Do	do	do	Gwinnett	Flouring and grist	9	116+	98	
Do	do	do	do	Saw	4	47	44	6
Do	do	do	Forsyth	Flouring and grist	8	154	137	
Do	do	do	do	Saw	4	54	36	
Do	do	do	Hall	do	4	45	90	
Do	do	do	do	Carriages and wagons	1	22	15	
Do	do	do	do	Flouring and grist	11	151	175	
Do	do	do	Milton	do	4	68	82	
Do	do	do	do	Saw	2	28	32	
Do	do	do	Lumpkin	do	7	141	75	
Do	do	do	do	Flouring and grist	10	183	134	
Do	do	do	do	Tannery	1	20	4	
Do	do	do	Habersham	Flouring and grist	1	14	10	
Do	do	do	do	Leather, curried	1	16	6	
Do	do	do	do	Woolen	1	20	12	
Do	do	do	White	Flouring and grist	1	10	15	
Flint river	Appalachicola river	do	Campbell	do	1	14	28	
Do	do	do	Clayton	do	5	90	44	
Do	do	do	Fayette	do	1	18	12	
Tributaries	Flint river	do	Campbell	do	3	70	50	
Do	do	do	Clayton	do	8	148	136	
Do	do	do	do	Saw	1	22	15	
Do	do	do	Henry	Flouring and grist	1	18	15	
Do	do	do	Spalding	do	2	13	40	
Do	do	do	Fayette	do	5	46½	109	
Do	do	do	Coweta	do	4	71	88	
Do	do	do	do	Saw	1	5	12	
Do	do	do	do	Tannery	1	30	16	
Do	do	do	Meriwether	Flouring and grist	11	171	138	
Do	do	do	do	Saw	1	16	15	
Do	do	do	Pike	Wheelwrighting	1	8	12	
Do	do	do	do	Flouring and grist	11	154½	276	
Do	do	do	Crawford	do	3	35	43	
Do	do	do	Upson	Cotton	2	29	115	
Do	do	do	do	Flouring and grist	15	191½	373	
Do	do	do	do	Saw	5	72	102	
Do	do	do	do	Tannery	1	10	5	
Do	do	do	Talbot	Flouring and grist	9	214	160	20
Do	do	do	Taylor	Cotton	1	12	40	
Do	do	do	Marion	Flouring and grist	4	33	52	
Do	do	do	do	Saw	1	12	20	
Do	do	do	Taylor	do	6	58	95	
Do	do	do	do	Flouring and grist	10	84+	129	
Do	do	do	Schley	do	6	53	70	
Do	do	do	Macon	do	5	51	102	
Do	do	do	do	Saw	1	8	30	
Do	do	do	Dooly	do	2	14	15	7

Table of utilized power on tributaries of the Appalachicola river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Tributaries	Flint river	Georgia	Dooly	Flouring and grist	2	8+	30	....
Do	...do	...do	Sumter	...do	7	51+	99	....
Do	...do	...do	Lee	...do	4	22½	41	....
Do	...do	...do	Webster	...do	8	66+	107	....
Do	...do	...do	...do	Saw	3	28	33	....
Do	...do	...do	Randolph	Flouring and grist	6	69	84	....
Do	...do	...do	Terrell	Saw	2	11+	30	....
Do	...do	...do	...do	Flouring and grist	2	14	15	....
Do	...do	...do	Calhoun	...do	3	10	50	....
Do	...do	...do	...do	Saw	1	6	12	....
Do	...do	...do	Dougherty	Flouring and grist	1	12	40	....
Do	...do	...do	...do	Saw	1	....	20	....
Do	...do	...do	Worth	...do	1	10	20	....
Do	...do	...do	...do	Flouring and grist	3	25	23	....
Do	...do	...do	Early	Cotton	1	40	45	....
Do	...do	...do	...do	Flouring and grist	5	57	62	....
Do	...do	...do	...do	Saw	1	9	10	....
Do	...do	...do	Miller	...do	1	8	12	....
Do	...do	...do	...do	Flouring and grist	1	8	40	....
Do	...do	...do	Baker	...do	3	14½	45	....
Do	...do	...do	Decatur	...do	1	5	8	....

Table of utilized power on sundry streams tributary to the eastern Gulf.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Escambia river	Gulf of Mexico	Alabama			0	....	....	....
Tributaries	Escambia river	...do	Bullock	Flouring and grist	1	10	15	....
Do	...do	...do	Butler	...do	13	131	143	....
Do	...do	...do	...do	Cotton-gins	4	30+	58	....
Do	...do	...do	...do	Saw	1	10	20	....
Do	...do	...do	Conecuh	...do	7	65	141	....
Do	...do	...do	...do	Cotton-gin	1	8	6	....
Do	...do	...do	...do	Flouring and grist	6	53	42	....
Do	...do	...do	Covington	...do	4	40	37	....
Do	...do	...do	...do	Saw	1	4½	20	....
Do	...do	...do	Crenshaw	Flouring and grist	23	237+	236	....
Do	...do	...do	Escambia	Saw	7	64	240	....
Do	...do	...do	Pike	...do	1	6	10	....
Do	...do	...do	...do	Flouring and grist	5	45	69	....
Do	...do	...do	...do	Cotton-gins	2	17	16	....
Yellow river	Gulf of Mexico	...do	Covington	Flouring and grist	1	10	10	....
Do	...do	...do	...do	Saw	1	8	20	....
Choctawhatchee river	...do	...do	Geneva	...do	1	10	20	....
Do	...do	...do	...do	Flouring and grist	1	....	7	....
Tributaries	Choctawhatchee river	...do	Barbour	...do	7	41+	84	....
Do	...do	...do	...do	Saw	1	10	10	....
Do	...do	...do	Bullock	Flouring and grist	1	22	97	....
Do	...do	...do	Coffee	...do	12	104	121	....
Do	...do	...do	...do	Saw	3	22	39	....
Do	...do	...do	Dale	Flouring and grist	7	50+	143	....
Do	...do	...do	Geneva	...do	6	41+	50	....
Do	...do	...do	...do	Saw	3	42	70	....
Do	...do	...do	Henry	...do	1	3	14	....
Do	...do	...do	...do	Flouring and grist	3	20	24	....
Do	...do	...do	Pike	...do	5	45	69	....
Ocklockonee river and tributaries	Gulf of Mexico	Georgia	Colquitt	...do	3	16	30	....
Do	...do	...do	Decatur	...do	4	64	50	....

Table of utilized power on sundry streams tributary to the eastern Gulf—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.
						Feet.	*H. P.*	*H. P.*
Ocklockonee river and tributaries	Gulf of Mexico	Georgia	Decatur	Saw	1	6	12	....
Do	...do	...do	Thomas	Flouring and grist	4	32	34	....
Ocilla river and tributaries	...do	...do	...do	...do	4	60½	50	....
Suwannee river	...do	...do			0	....	....	....
Tributaries	Suwannee river	...do	Berrien	Woolen	1	12	12	....
Do	...do	...do	...do	Flouring and grist	10	82	145	....
Do	...do	...do	...do	Saw	1	9	10	....
Do	...do	...do	Brooks	Woolen	1	....	12	....
Do	...do	...do	...do	Saw	1	10	10	....
Do	...do	...do	...do	Flouring and grist	7	43+	54	....
Do	...do	...do	Clinch	...do	1	7	15	....
Do	...do	...do	Echols	...do	1	6	6	....
Do	...do	...do	...do	Cotton-gin	1	12	6	....
Do	...do	...do	Lowndes	Saw	1	10	10	....
Do	...do	...do	...do	Flouring and grist	8	80	77	....
Do	...do	...do	Wilcox	...do	1	6	4	....
Other streams	Gulf of Mexico	Alabama	Baldwin	Saw	1	10	40	....
Do	...do	...do	Mobile	Flouring and grist	1	15	40	....

Summary of power utilized on streams tributary to the eastern Gulf (not including any returns for Florida).

Stream.	COTTON-MILLS.			WOOLEN-MILLS.			FLOURING- AND GRIST-MILLS.			SAW-MILLS.			SUNDRY OTHER ESTABLISHMENTS.			TOTAL.		
	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.	Number of mills.	Water-power utilized.	Auxiliary steam-power.
		H. P.	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*		*H. P.*	*H. P.*
Tributaries of the Alabama river	6	1,658	.....	10	79	......	408	6,515	60	84	1,470	......	44	447	......	552	10,169	60
Chattahoochee river and tributaries	13	3,065	.....	5	166	......	270	4,951	......	68	1,105	6	32	498	......	388	9,785	5
Flint river and tributaries	4	200	......	......	......	......	151	2,530	20	28	441	7	3	33	......	186	3,204	27
Sundry other streams	......	......	......	2	24	......	142	1,684	......	32	686	......	8	86	......	184	2,480	......
Total	23	4,923	.....	17	269	......	971	15,680	80	212	3,702	13	87	1,064	......	1,310	25,638	93

NOTE.—"Sundry other establishments" include cotton-gins (48), tanneries (14), paper-mills (1); blacksmithing, carpentering, machine, sash-, door-, and blind-, wheelwrighting, and general wood-working shops; founderies, iron-works, and pumping-works for water-supply (1 each); and establishments for the manufacture of cotton-gins, building-materials, furniture, carriages and wagons, stone- and earthen-ware.

INDEX TO REPORT ON WATER-POWER OF THE EASTERN GULF SLOPE.

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